

**ANTISENSE MODULATION OF SURVIVIN EXPRESSION****RELATED APPLICATIONS**

This application is a continuation-in-part of U.S. Serial No. 09/496,694, filed February 2, 2000, which is a continuation-in-part of U.S. Serial No. 09/286,407 filed April 5, 1999, issued as U.S. Patent 6,165,788, which is a continuation-in-part of U.S. Serial No. 09/163,162 filed September 29, 1998, issued as U.S. Patent 6,077,709.

**FIELD OF THE INVENTION**

The present invention provides compositions and methods for modulating the expression of Survivin. In particular, this invention relates to antisense compounds, particularly oligonucleotides, specifically hybridizable with nucleic acids encoding human Survivin. Such oligonucleotides have been shown to modulate the expression of Survivin.

**BACKGROUND OF THE INVENTION**

A hallmark feature of cancerous cells is uncontrolled proliferation. Among the differences that have been discovered between tumor and normal cells is resistance to the process of programmed cell death, also known as apoptosis (Ambrosini et al., *Nat. Med.*, **1997**, 3, 917-921). Apoptosis is a process multicellular organisms have evolved to prevent uncontrolled cell proliferation as well as to eliminate cells that have become sick, deleterious, or are no longer necessary. The process of apoptosis involves a multistep cascade in which cells are degraded from within through the concerted action of proteolytic enzymes and DNA endonucleases, resulting in the formation of apoptotic bodies that are then removed by scavenger cells. Research to date has shown that much of the intracellular degradation is carried out through

the action of the caspases, a family of proteolytic enzymes that cleave adjacent to aspartate residues (Cohen, *Biochemistry Journal*, 1997, 326, 1-16).

The finding that most tumor cells display resistance to the apoptotic process has led to the view that therapeutic strategies aimed at attenuating the resistance of tumor cells to apoptosis could represent a novel means to halt the spread of neoplastic cells (Ambrosini et al., *Nat. Med.*, 1997, 3, 917-921). One of the mechanisms through which tumor cells are believed to acquire resistance to apoptosis is by overexpression of Survivin, a recently described member of the IAP (inhibitor of apoptosis) caspase inhibitor family. To date, overexpression of Survivin has been detected in tumors of the lung, colon, pancreas, prostate, breast, stomach, non-Hodgkin's lymphoma, and neuroblastoma (Adida et al., *Lancet*, 1998, 351, 882-883; Ambrosini et al., *Nat. Med.*, 1997, 3, 917-921; Lu et al., *Cancer Res.*, 1998, 58, 1808-1812). A more detailed analysis has been performed in neuroblastoma where it was found that Survivin overexpression segregated with tumor histologies known to associate with poor prognosis (Adida et al., *Lancet*, 1998, 351, 882-883). Finally, Ambrosini et al. describe transfection of HeLa cells with an expression vector containing a 708 nt fragment of the human cDNA encoding effector cell protease receptor 1 (EPR-1), the coding sequence of which is extensively complementary to the coding strand of Survivin (Ambrosini et al., *J. Bio. Chem.*, 1998, 273, 11177-11182) and which potentially acts as a Survivin antisense RNA. This construct caused a reduction in cell viability. Methods for modulating apoptosis and for reducing the severity of a pathological state mediated by Survivin using agents that modulate amounts or activity of Survivin are disclosed in WO 98/22589, which also discloses the EPR-1 coding strand/Survivin antisense construct described by Ambrosini et al., *supra*.

Survivin has recently been found to play a role in cell cycle regulation. It has been found to be expressed in the G2/M phase of the cell cycle in a cycle-regulated manner, and associates with microtubules of the mitotic spindle.

5 Disruption of this interaction results in loss of Survivin's anti-apoptotic function and increased caspase-3 activity during mitosis. Caspase-3 is associated with apoptotic cell death. It is therefore believed that Survivin may counteract a default induction of apoptosis in G2/M phase. It is believed  
10 that the overexpression of Survivin in cancer may overcome this apoptotic checkpoint, allowing undesired survival and division of cancerous cells. The Survivin antisense construct described by Ambrosini above was found to downregulate endogenous Survivin in HeLa cells and to increase caspase-3-  
15 dependent apoptosis in cells in G2/M phase. Li et al., Nature, 1998, 396, 580-584.

As a result of these advances in the understanding of apoptosis and the role that Survivin expression is believed to play in conferring a growth advantage to a wide variety of  
20 tumor cell types, there is a great desire to provide compositions of matter which can modulate the expression of Survivin. It is greatly desired to provide methods of diagnosis and detection of nucleic acids encoding Survivin in animals. It is also desired to provide methods of diagnosis  
25 and treatment of conditions arising from Survivin expression. In addition, improved research kits and reagents for detection and study of nucleic acids encoding Survivin are desired.

Currently, there are no known therapeutic agents which effectively inhibit the synthesis of Survivin. Consequently,  
30 there is a long-felt need for agents capable of effectively inhibiting Survivin expression in tumor cells. Antisense oligonucleotides against Survivin may therefore prove to be uniquely useful in a number of therapeutic, diagnostic and research applications.

**SUMMARY OF THE INVENTION**

The present invention is directed to antisense compounds, particularly oligonucleotides, which are targeted to a nucleic acid encoding Survivin, and which modulate the expression of Survivin. Pharmaceutical and other compositions comprising the antisense compounds of the invention are also provided. Further provided are methods of modulating the expression of Survivin in cells or tissues comprising contacting said cells or tissues with one or more of the antisense compounds or compositions of the invention. Further provided are methods of treating an animal, particularly a human, suspected of having or being prone to a disease or condition associated with expression of Survivin by administering a therapeutically or prophylactically effective amount of one or more of the antisense compounds or compositions of the invention.

One embodiment of the present invention is a method of inhibiting the expression of Survivin in human cells or tissues comprising contacting human cells or tissues with an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that expression of Survivin is inhibited.

The present invention also provides a method of treating an animal having a disease or condition associated with Survivin comprising administering to an animal having a disease or condition associated with Survivin a therapeutically or prophylactically effective amount of an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that expression of Survivin is inhibited. Preferably, the disease or condition is a hyperproliferative condition. In one embodiment, the hyperproliferative condition is cancer

Another embodiment of the present invention is a method of treating a human having a disease or condition characterized by a reduction in apoptosis comprising

administering to a human having a disease or condition characterized by a reduction in apoptosis a prophylactically or therapeutically effective amount of antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that expression of survivin is inhibited.

The present invention also provides a method of modulating apoptosis in a cell comprising contacting a cell with an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that apoptosis is modulated.

Still another embodiment of the invention is a method of modulating cytokinesis in a cell comprising contacting a cell with an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that cytokinesis is modulated.

The present invention also provides a method of modulating the cell cycle in a cell comprising contacting a cell with an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin so that the cell cycle is modulated.

In still another embodiment of the invention, there is provided a method of inhibiting the proliferation of cells comprising contacting cells with an effective amount of an antisense compound 8 to 30 nucleobases in length targeted to a nucleic acid molecule encoding human survivin, so that proliferation of the cells is inhibited. In one embodiment, the cells are cancer cells. The method may further comprise administering to the patient a chemotherapeutic agent.

Preferably, the modulation of apoptosis is sensitization to an apoptotic stimulus. In one embodiment, the apoptotic stimulus is a cytotoxic chemotherapeutic agent. The method may further comprise contacting the cells with a chemotherapeutic agent. Preferably, the chemotherapeutic agent is taxol or cisplatin.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention employs oligomeric antisense compounds, particularly oligonucleotides, for use in modulating the function of nucleic acid molecules encoding Survivin, ultimately modulating the amount of Survivin produced. This is accomplished by providing antisense compounds which specifically hybridize with one or more nucleic acids encoding Survivin. As used herein, the terms "target nucleic acid" and "nucleic acid encoding Survivin" encompass DNA encoding Survivin, RNA (including pre-mRNA and mRNA) transcribed from such DNA, and also cDNA derived from such RNA. The specific hybridization of an oligomeric compound with its target nucleic acid interferes with the normal function of the nucleic acid. This modulation of function of a target nucleic acid by compounds which specifically hybridize to it is generally referred to as "antisense". The functions of DNA to be interfered with include replication and transcription. The functions of RNA to be interfered with include all vital functions such as, for example, translocation of the RNA to the site of protein translation, translation of protein from the RNA, splicing of the RNA to yield one or more mRNA species, and catalytic activity which may be engaged in or facilitated by the RNA. The overall effect of such interference with target nucleic acid function is modulation of the expression of Survivin. In the context of the present invention, "modulation" means either an increase (stimulation) or a decrease (inhibition) in the expression of a gene. In the context of the present invention, inhibition is the preferred form of modulation of gene expression and mRNA is a preferred target.

It is preferred to target specific nucleic acids for antisense. "Targeting" an antisense compound to a particular nucleic acid, in the context of this invention, is a multistep process. The process usually begins with the identification of a nucleic acid sequence whose function is to be modulated.

This may be, for example, a cellular gene (or mRNA transcribed from the gene) whose expression is associated with a particular disorder or disease state, or a nucleic acid molecule from an infectious agent. In the present invention, 5 the target is a nucleic acid molecule encoding Survivin. The targeting process also includes determination of a site or sites within this gene for the antisense interaction to occur such that the desired effect, e.g., detection or modulation of expression of the protein, will result. Within the context 10 of the present invention, a preferred intragenic site is the region encompassing the translation initiation or termination codon of the open reading frame (ORF) of the gene. Since, as is known in the art, the translation initiation codon is typically 5'-AUG (in transcribed mRNA molecules; 5'-ATG in the 15 corresponding DNA molecule), the translation initiation codon is also referred to as the "AUG codon," the "start codon" or the "AUG start codon". A minority of genes have a translation initiation codon having the RNA sequence 5'-GUG, 5'-UUG or 5'-CUG, and 5'-AUA, 5'-ACG and 5'-CUG have been shown to 20 function *in vivo*. Thus, the terms "translation initiation codon" and "start codon" can encompass many codon sequences, even though the initiator amino acid in each instance is typically methionine (in eukaryotes) or formylmethionine (in prokaryotes). It is also known in the art that eukaryotic and 25 prokaryotic genes may have two or more alternative start codons, any one of which may be preferentially utilized for translation initiation in a particular cell type or tissue, or under a particular set of conditions. In the context of the invention, "start codon" and "translation initiation 30 codon" refer to the codon or codons that are used *in vivo* to initiate translation of an mRNA molecule transcribed from a gene encoding Survivin, regardless of the sequence(s) of such codons.

It is also known in the art that a translation 35 termination codon (or "stop codon") of a gene may have one of

three sequences, i.e., 5'-UAA, 5'-UAG and 5'-UGA (the corresponding DNA sequences are 5'-TAA, 5'-TAG and 5'-TGA, respectively). The terms "start codon region" and "translation initiation codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation initiation codon. Similarly, the terms "stop codon region" and "translation termination codon region" refer to a portion of such an mRNA or gene that encompasses from about 25 to about 50 contiguous nucleotides in either direction (i.e., 5' or 3') from a translation termination codon.

The open reading frame (ORF) or "coding region," which is known in the art to refer to the region between the translation initiation codon and the translation termination codon, is also a region which may be targeted effectively. Other target regions include the 5' untranslated region (5'UTR), known in the art to refer to the portion of an mRNA in the 5' direction from the translation initiation codon, and thus including nucleotides between the 5' cap site and the translation initiation codon of an mRNA or corresponding nucleotides on the gene, and the 3' untranslated region (3'UTR), known in the art to refer to the portion of an mRNA in the 3' direction from the translation termination codon, and thus including nucleotides between the translation termination codon and 3' end of an mRNA or corresponding nucleotides on the gene. The 5' cap of an mRNA comprises an N7-methylated guanosine residue joined to the 5'-most residue of the mRNA via a 5'-5' triphosphate linkage. The 5' cap region of an mRNA is considered to include the 5' cap structure itself as well as the first 50 nucleotides adjacent to the cap. The 5' cap region may also be a preferred target region.

Although some eukaryotic mRNA transcripts are directly translated, many contain one or more regions, known as



"introns," which are excised from a transcript before it is translated. The remaining (and therefore translated) regions are known as "exons" and are spliced together to form a continuous mRNA sequence. mRNA splice sites, i.e., intron-  
5 exon junctions, may also be preferred target regions, and are particularly useful in situations where aberrant splicing is implicated in disease, or where an overproduction of a particular mRNA splice product is implicated in disease.

Aberrant fusion junctions due to rearrangements or  
10 deletions are also preferred targets. It has also been found that introns can also be effective, and therefore preferred, target regions for antisense compounds targeted, for example, to DNA or pre-mRNA.

Once one or more target sites have been identified,  
15 oligonucleotides are chosen which are sufficiently complementary to the target, i.e., hybridize sufficiently well and with sufficient specificity, to give the desired effect.

In the context of this invention, "hybridization" means hydrogen bonding, which may be Watson-Crick, Hoogsteen or  
20 reversed Hoogsteen hydrogen bonding, between complementary nucleoside or nucleotide bases. For example, adenine and thymine are complementary nucleobases which pair through the formation of hydrogen bonds. "Complementary," as used herein, refers to the capacity for precise pairing between two  
25 nucleotides. For example, if a nucleotide at a certain position of an oligonucleotide is capable of hydrogen bonding with a nucleotide at the same position of a DNA or RNA molecule, then the oligonucleotide and the DNA or RNA are considered to be complementary to each other at that position.  
30 The oligonucleotide and the DNA or RNA are complementary to each other when a sufficient number of corresponding positions in each molecule are occupied by nucleotides which can hydrogen bond with each other. Thus, "specifically hybridizable" and "complementary" are terms which are used to  
35 indicate a sufficient degree of complementarity or precise

pairing such that stable and specific binding occurs between the oligonucleotide and the DNA or RNA target. It is understood in the art that the sequence of an antisense compound need not be 100% complementary to that of its target  
5 nucleic acid to be specifically hybridizable. An antisense compound is specifically hybridizable when binding of the compound to the target DNA or RNA molecule interferes with the normal function of the target DNA or RNA to cause a loss of utility, and there is a sufficient degree of complementarity  
10 to avoid non-specific binding of the antisense compound to non-target sequences under conditions in which specific binding is desired, i.e., under physiological conditions in the case of *in vivo* assays or therapeutic treatment, or in the case of *in vitro* assays, under conditions in which the assays  
15 are performed.

Antisense compounds are commonly used as research reagents and diagnostics. For example, antisense oligonucleotides, which are able to inhibit gene expression with exquisite specificity, are often used by those of  
20 ordinary skill to elucidate the function of particular genes. Antisense compounds are also used, for example, to distinguish between functions of various members of a biological pathway. Antisense modulation has, therefore, been harnessed for research use.

25 The specificity and sensitivity of antisense is also harnessed by those of skill in the art for therapeutic uses. Antisense oligonucleotides have been employed as therapeutic moieties in the treatment of disease states in animals and man. Antisense oligonucleotides have been safely and  
30 effectively administered to humans and numerous clinical trials are presently underway. It is thus established that oligonucleotides can be useful therapeutic modalities that can be configured to be useful in treatment regimes for treatment of cells, tissues and animals, especially humans.

In the context of this invention, the term "oligonucleotide" refers to an oligomer or polymer of ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) or mimetics thereof. This term includes oligonucleotides  
5 composed of naturally-occurring nucleobases, sugars and covalent internucleoside (backbone) linkages as well as oligonucleotides having non-naturally-occurring portions which function similarly. Such modified or substituted oligonucleotides are often preferred over native forms because  
10 of desirable properties such as, for example, enhanced cellular uptake, enhanced affinity for nucleic acid target and increased stability in the presence of nucleases.

While antisense oligonucleotides are a preferred form of antisense compound, the present invention comprehends other  
15 oligomeric antisense compounds, including but not limited to oligonucleotide mimetics such as are described below. The antisense compounds in accordance with this invention preferably comprise from about 8 to about 30 nucleobases. Particularly preferred are antisense oligonucleotides  
20 comprising from about 8 to about 30 nucleobases (i.e. from about 8 to about 30 linked nucleosides). Preferred embodiments comprise at least an 8-nucleobase portion of a sequence of an antisense compound which inhibits expression of Survivin. As is known in the art, a nucleoside is a base-  
25 sugar combination. The base portion of the nucleoside is normally a heterocyclic base. The two most common classes of such heterocyclic bases are the purines and the pyrimidines. Nucleotides are nucleosides that further include a phosphate group covalently linked to the sugar portion of the  
30 nucleoside. For those nucleosides that include a pentofuranosyl sugar, the phosphate group can be linked to either the 2', 3' or 5' hydroxyl moiety of the sugar. In forming oligonucleotides, the phosphate groups covalently link adjacent nucleosides to one another to form a linear polymeric  
35 compound. In turn the respective ends of this linear

polymeric structure can be further joined to form a circular structure, however, open linear structures are generally preferred. Within the oligonucleotide structure, the phosphate groups are commonly referred to as forming the  
5 internucleoside backbone of the oligonucleotide. The normal linkage or backbone of RNA and DNA is a 3' to 5' phosphodiester linkage.

Specific examples of preferred antisense compounds useful in this invention include oligonucleotides containing  
10 modified backbones or non-natural internucleoside linkages. As defined in this specification, oligonucleotides having modified backbones include those that retain a phosphorus atom in the backbone and those that do not have a phosphorus atom in the backbone. For the purposes of this specification, and  
15 as sometimes referenced in the art, modified oligonucleotides that do not have a phosphorus atom in their internucleoside backbone can also be considered to be oligonucleosides.

Preferred modified oligonucleotide backbones include, for example, phosphorothioates, chiral phosphorothioates, phosphorodithioates, phosphotriesters, aminoalkylphosphotriesters, methyl and other alkyl phosphonates including 3'-alkylene phosphonates and chiral phosphonates, phosphinates, phosphoramidates including 3'-amino phosphoramidate and aminoalkylphosphoramidates, thionophosphoramidates, thiono-  
20 alkylphosphonates, thionoalkylphosphotriesters, and boranophosphates having normal 3'-5' linkages, 2'-5' linked analogs of these, and those having inverted polarity wherein the adjacent pairs of nucleoside units are linked 3'-5' to 5'-3' or 2'-5' to 5'-2'. Various salts, mixed salts and free acid  
25 forms are also included.  
30

Representative United States patents that teach the preparation of the above phosphorus-containing linkages include, but are not limited to, U.S. Patents 3,687,808; 4,469,863; 4,476,301; 5,023,243; 5,177,196; 5,188,897;  
35 5,264,423; 5,276,019; 5,278,302; 5,286,717; 5,321,131;

5,399,676; 5,405,939; 5,453,496; 5,455,233; 5,466,677; 5,476,925; 5,519,126; 5,536,821; 5,541,306; 5,550,111; 5,563,253; 5,571,799; 5,587,361; and 5,625,050, each of which is herein incorporated by reference.

5 Preferred modified oligonucleotide backbones that do not include a phosphorus atom therein have backbones that are formed by short chain alkyl or cycloalkyl internucleoside linkages, mixed heteroatom and alkyl or cycloalkyl internucleoside linkages, or one or more short chain  
10 heteroatomic or heterocyclic internucleoside linkages. These include those having morpholino linkages (formed in part from the sugar portion of a nucleoside); siloxane backbones; sulfide, sulfoxide and sulfone backbones; formacetyl and thioformacetyl backbones; methylene formacetyl and  
15 thioformacetyl backbones; alkene containing backbones; sulfamate backbones; methyleneimino and methylenehydrazino backbones; sulfonate and sulfonamide backbones; amide backbones; and others having mixed N, O, S and CH<sub>2</sub> component parts. Representative United States patents that teach the  
20 preparation of the above oligonucleosides include, but are not limited to, U.S. Patents 5,034,506; 5,166,315; 5,185,444; 5,214,134; 5,216,141; 5,235,033; 5,264,562; 5,264,564; 5,405,938; 5,434,257; 5,466,677; 5,470,967; 5,489,677; 5,541,307; 5,561,225; 5,596,086; 5,602,240; 5,610,289;  
25 5,602,240; 5,608,046; 5,610,289; 5,618,704; 5,623,070; 5,663,312; 5,633,360; 5,677,437; and 5,677,439, each of which is herein incorporated by reference.

In other preferred oligonucleotide mimetics, both the sugar and the internucleoside linkage, i.e., the backbone, of  
30 the nucleotide units are replaced with novel groups. The base units are maintained for hybridization with an appropriate nucleic acid target compound. One such oligomeric compound, an oligonucleotide mimetic that has been shown to have excellent hybridization properties, is referred to as a  
35 peptide nucleic acid (PNA). In PNA compounds, the sugar-

backbone of an oligonucleotide is replaced with an amide containing backbone, in particular an aminoethylglycine backbone. The nucleobases are retained and are bound directly or indirectly to aza nitrogen atoms of the amide portion of the backbone. Representative United States patents that teach the preparation of PNA compounds include, but are not limited to, U.S. Patents 5,539,082; 5,714,331; and 5,719,262, each of which is herein incorporated by reference. Further teaching of PNA compounds can be found in Nielsen et al., *Science*, 1991, 254, 1497-1500.

Most preferred embodiments of the invention are oligonucleotides with phosphorothioate backbones and oligonucleosides with heteroatom backbones, and in particular -CH<sub>2</sub>-NH-O-CH<sub>2</sub>-, -CH<sub>2</sub>-N(CH<sub>3</sub>)-O-CH<sub>2</sub>- [known as a methylene (methylimino) or MMI backbone], -CH<sub>2</sub>-O-N(CH<sub>3</sub>)-CH<sub>2</sub>-, -CH<sub>2</sub>-N(CH<sub>3</sub>)-N(CH<sub>3</sub>)-CH<sub>2</sub>- and -O-N(CH<sub>3</sub>)-CH<sub>2</sub>-CH<sub>2</sub>- [wherein the native phosphodiester backbone is represented as -O-P-O-CH<sub>2</sub>-] of the above referenced U.S. Patent 5,489,677, and the amide backbones of the above referenced U.S. Patent 5,602,240. Also preferred are oligonucleotides having morpholino backbone structures of the above-referenced U.S. Patent 5,034,506.

Modified oligonucleotides may also contain one or more substituted sugar moieties. Preferred oligonucleotides comprise one of the following at the 2' position: OH; F; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; O-, S- or N-alkynyl; or O-alkyl-O-alkyl, wherein the alkyl, alkenyl and alkynyl may be substituted or unsubstituted C<sub>1</sub> to C<sub>10</sub> alkyl or C<sub>2</sub> to C<sub>10</sub> alkenyl and alkynyl. Particularly preferred are O[(CH<sub>2</sub>)<sub>n</sub>O]<sub>m</sub>CH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>OCH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>, O(CH<sub>2</sub>)<sub>n</sub>CH<sub>3</sub>, O(CH<sub>2</sub>)<sub>n</sub>ONH<sub>2</sub>, and O(CH<sub>2</sub>)<sub>n</sub>ON[(CH<sub>2</sub>)<sub>n</sub>CH<sub>3</sub>]<sub>2</sub>, where n and m are from 1 to about 10. Other preferred oligonucleotides comprise one of the following at the 2' position: C<sub>1</sub> to C<sub>10</sub> lower alkyl, substituted lower alkyl, alkaryl, aralkyl, O-alkaryl or O-aralkyl, SH, SCH<sub>3</sub>, OCN, Cl, Br, CN, CF<sub>3</sub>, OCF<sub>3</sub>, SOCH<sub>3</sub>, SO<sub>2</sub>CH<sub>3</sub>, ONO<sub>2</sub>, NO<sub>2</sub>, N<sub>3</sub>, NH<sub>2</sub>, heterocycloalkyl, heterocycloalkaryl,

aminoalkylamino, polyalkylamino, substituted silyl, an RNA cleaving group, a reporter group, an intercalator, a group for improving the pharmacokinetic properties of an oligonucleotide, or a group for improving the pharmacodynamic properties of an oligonucleotide, and other substituents having similar properties. A preferred modification includes 2'-methoxyethoxy (2'-O-CH<sub>2</sub>CH<sub>2</sub>OCH<sub>3</sub>, also known as 2'-O-(2-methoxyethyl) or 2'-MOE) (Martin et al., *Helv. Chim. Acta*, **1995**, 78, 486-504) i.e., an alkoxyalkoxy group. A further preferred modification includes 2'-dimethylaminoethoxy, i.e., a O(CH<sub>2</sub>)<sub>2</sub>ON(CH<sub>3</sub>)<sub>2</sub> group, also known as 2'-DMAOE, as described in United States patent application Serial Number 09/016,520, filed on January 30, 1998, which is commonly owned with the instant application and the contents of which are herein incorporated by reference.

Other preferred modifications include 2'-methoxy (2'-O-CH<sub>3</sub>), 2'-aminopropoxy (2'-OCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>) and 2'-fluoro (2'-F). Similar modifications may also be made at other positions on the oligonucleotide, particularly the 3' position of the sugar on the 3' terminal nucleotide or in 2'-5' linked oligonucleotides and the 5' position of 5' terminal nucleotide. Oligonucleotides may also have sugar mimetics such as cyclobutyl moieties in place of the pentofuranosyl sugar. Representative United States patents that teach the preparation of such modified sugar structures include, but are not limited to, U.S. Patents 4,981,957; 5,118,800; 5,319,080; 5,359,044; 5,393,878; 5,446,137; 5,466,786; 5,514,785; 5,519,134; 5,567,811; 5,576,427; 5,591,722; 5,597,909; 5,610,300; 5,627,053; 5,639,873; 5,646,265; 5,658,873; 5,670,633; and 5,700,920, each of which is herein incorporated by reference in its entirety.

Oligonucleotides may also include nucleobase (often referred to in the art simply as "base") modifications or substitutions. As used herein, "unmodified" or "natural" nucleobases include the purine bases adenine (A) and guanine

(G), and the pyrimidine bases thymine (T), cytosine (C) and uracil (U). Modified nucleobases include other synthetic and natural nucleobases such as 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2-aminoadenine, 6-methyl and other alkyl derivatives of adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-halouracil and cytosine, 5-propynyl uracil and cytosine, 6-azo uracil, cytosine and thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo, 8-amino, 8-thiol, 8-thioalkyl, 8-hydroxyl and other 8-substituted adenines and guanines, 5-halo particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, 7-deazaguanine and 7-deazaadenine and 3-deazaguanine and 3-deazaadenine. Further nucleobases include those disclosed in U. S. Patent 3,687,808, those disclosed in *The Concise Encyclopedia Of Polymer Science And Engineering*, pages 858-859, Kroschwitz, J.I., ed. John Wiley & Sons, 1990, those disclosed by Englisch et al., *Angewandte Chemie*, International Edition, 1991, 30, 613, and those disclosed by Sanghvi, Y.S., Chapter 15, *Antisense Research and Applications*, pages 289-302, Crooke, S.T. and Lebleu, B. , ed., CRC Press, 1993. Certain of these nucleobases are particularly useful for increasing the binding affinity of the oligomeric compounds of the invention. These include 5-substituted pyrimidines, 6-azapyrimidines and N-2, N-6 and O-6 substituted purines, including 2-aminopropyladenine, 5-propynyluracil and 5-propynylcytosine. 5-methylcytosine substitutions have been shown to increase nucleic acid duplex stability by 0.6-1.2EC (Sanghvi, Y.S., Crooke, S.T. and Lebleu, B., eds., *Antisense Research and Applications*, CRC Press, Boca Raton, 1993, pp. 276-278) and are presently preferred base substitutions, even more



particularly when combined with 2'-O-methoxyethyl sugar modifications.

Representative United States patents that teach the preparation of certain of the above noted modified nucleobases as well as other modified nucleobases include, but are not limited to, the above noted U.S. Patent 3,687,808, as well as U.S. Patents 4,845,205; 5,130,302; 5,134,066; 5,175,273; 5,367,066; 5,432,272; 5,457,187; 5,459,255; 5,484,908; 5,502,177; 5,525,711; 5,552,540; 5,587,469; 5,594,121, 5,596,091; 5,614,617; 5,681,941; and 5,750,692, each of which is herein incorporated by reference.

Another modification of the oligonucleotides of the invention involves chemically linking to the oligonucleotide one or more moieties or conjugates which enhance the activity, cellular distribution or cellular uptake of the oligonucleotide. Such moieties include but are not limited to lipid moieties such as a cholesterol moiety (Letsinger et al., *Proc. Natl. Acad. Sci. USA*, **1989**, 86, 6553-6556), cholic acid (Manoharan et al., *Bioorg. Med. Chem. Lett.*, **1994**, 4, 1053-1060), a thioether, e.g., hexyl-S-tritylthiol (Manoharan et al., *Ann. N.Y. Acad. Sci.*, **1992**, 660, 306-309; Manoharan et al., *Bioorg. Med. Chem. Lett.*, **1993**, 3, 2765-2770), a thiocholesterol (Oberhauser et al., *Nucl. Acids Res.*, **1992**, 20, 533-538), an aliphatic chain, e.g., dodecandiol or undecyl residues (Saison-Behmoaras et al., *EMBO J.*, **1991**, 10, 1111-1118; Kabanov et al., *FEBS Lett.*, **1990**, 259, 327-330; Svinarchuk et al., *Biochimie*, **1993**, 75, 49-54), a phospholipid, e.g., di-hexadecyl-rac-glycerol or triethyl-ammonium 1,2-di-O-hexadecyl-rac-glycero-3-H-phosphonate (Manoharan et al., *Tetrahedron Lett.*, **1995**, 36, 3651-3654; Shea et al., *Nucl. Acids Res.*, **1990**, 18, 3777-3783), a polyamine or a polyethylene glycol chain (Manoharan et al., *Nucleosides & Nucleotides*, **1995**, 14, 969-973), or adamantane acetic acid (Manoharan et al., *Tetrahedron Lett.*, **1995**, 36,

3651-3654), a palmityl moiety (Mishra et al., *Biochim. Biophys. Acta*, **1995**, 1264, 229-237), or an octadecylamine or hexylamino-carbonyl-oxysterol moiety (Crooke et al., *J. Pharmacol. Exp. Ther.*, **1996**, 277, 923-937).

5 Representative United States patents that teach the preparation of such oligonucleotide conjugates include, but are not limited to, U.S. Patents 4,828,979; 4,948,882; 5,218,105; 5,525,465; 5,541,313; 5,545,730; 5,552,538; 5,578,717; 5,580,731; 5,580,731; 5,591,584; 5,109,124; 10 5,118,802; 5,138,045; 5,414,077; 5,486,603; 5,512,439; 5,578,718; 5,608,046; 4,587,044; 4,605,735; 4,667,025; 4,762,779; 4,789,737; 4,824,941; 4,835,263; 4,876,335; 4,904,582; 4,958,013; 5,082,830; 5,112,963; 5,214,136; 5,082,830; 5,112,963; 5,214,136; 5,245,022; 5,254,469; 15 5,258,506; 5,262,536; 5,272,250; 5,292,873; 5,317,098; 5,371,241; 5,391,723; 5,416,203; 5,451,463; 5,510,475; 5,512,667; 5,514,785; 5,565,552; 5,567,810; 5,574,142; 5,585,481; 5,587,371; 5,595,726; 5,597,696; 5,599,923; 5,599,928 and 5,688,941, each of which is herein incorporated 20 by reference.

It is not necessary for all positions in a given compound to be uniformly modified, and in fact more than one of the aforementioned modifications may be incorporated in a single compound or even at a single nucleoside within an 25 oligonucleotide. The present invention also includes antisense compounds which are chimeric compounds. "Chimeric" antisense compounds or "chimeras," in the context of this invention, are antisense compounds, particularly oligonucleotides, which contain two or more chemically 30 distinct regions, each made up of at least one monomer unit, i.e., a nucleotide in the case of an oligonucleotide compound. These oligonucleotides typically contain at least one region wherein the oligonucleotide is modified so as to confer upon the oligonucleotide increased resistance to nuclease 35 degradation, increased cellular uptake, and/or increased

binding affinity for the target nucleic acid. An additional region of the oligonucleotide may serve as a substrate for enzymes capable of cleaving RNA:DNA or RNA:RNA hybrids. By way of example, RNase H is a cellular endonuclease which cleaves the RNA strand of an RNA:DNA duplex. Activation of RNase H, therefore, results in cleavage of the RNA target, thereby greatly enhancing the efficiency of oligonucleotide inhibition of gene expression. Consequently, comparable results can often be obtained with shorter oligonucleotides when chimeric oligonucleotides are used, compared to phosphorothioate deoxyoligonucleotides hybridizing to the same target region. Cleavage of the RNA target can be routinely detected by gel electrophoresis and, if necessary, associated nucleic acid hybridization techniques known in the art.

Chimeric antisense compounds of the invention may be formed as composite structures of two or more oligonucleotides, modified oligonucleotides, oligonucleosides and/or oligonucleotide mimetics as described above. Such compounds have also been referred to in the art as hybrids or gapmers. Representative United States patents that teach the preparation of such hybrid structures include, but are not limited to, U.S. Patents 5,013,830; 5,149,797; 5,220,007; 5,256,775; 5,366,878; 5,403,711; 5,491,133; 5,565,350; 5,623,065; 5,652,355; 5,652,356; and 5,700,922, each of which is herein incorporated by reference in its entirety.

The antisense compounds used in accordance with this invention may be conveniently and routinely made through the well-known technique of solid phase synthesis. Equipment for such synthesis is sold by several vendors including, for example, Applied Biosystems (Foster City, CA). Any other means for such synthesis known in the art may additionally or alternatively be employed. It is well known to use similar techniques to prepare oligonucleotides such as the phosphorothioates and alkylated derivatives.

The antisense compounds of the invention are synthesized in vitro and do not include antisense compositions of biological origin, or genetic vector constructs designed to direct the *in vivo* synthesis of antisense molecules.

5 The compounds of the invention may also be admixed, encapsulated, conjugated or otherwise associated with other molecules, molecule structures or mixtures of compounds, as for example, liposomes, receptor targeted molecules, oral, rectal, topical or other formulations, for assisting in  
10 uptake, distribution and/or absorption. Representative United States patents that teach the preparation of such uptake, distribution and/or absorption assisting formulations include, but are not limited to, U.S. Patents 5,108,921; 5,354,844; 5,416,016; 5,459,127; 5,521,291; 5,543,158; 5,547,932;  
15 5,583,020; 5,591,721; 4,426,330; 4,534,899; 5,013,556; 5,108,921; 5,213,804; 5,227,170; 5,264,221; 5,356,633; 5,395,619; 5,416,016; 5,417,978; 5,462,854; 5,469,854; 5,512,295; 5,527,528; 5,534,259; 5,543,152; 5,556,948; 5,580,575; and 5,595,756, each of which is herein incorporated  
20 by reference.

The antisense compounds of the invention encompass any pharmaceutically acceptable salts, esters, or salts of such esters, or any other compound which, upon administration to an animal including a human, is capable of providing (directly  
25 or indirectly) the biologically active metabolite or residue thereof. Accordingly, for example, the disclosure is also drawn to prodrugs and pharmaceutically acceptable salts of the compounds of the invention, pharmaceutically acceptable salts of such prodrugs, and other bioequivalents.

30 The term "prodrug" indicates a therapeutic agent that is prepared in an inactive form that is converted to an active form (i.e., drug) within the body or cells thereof by the action of endogenous enzymes or other chemicals and/or conditions. In particular, prodrug versions of the  
35 oligonucleotides of the invention are prepared as SATE

[(S-acetyl-2-thioethyl) phosphate] derivatives according to the methods disclosed in WO 93/24510 to Gosselin et al., published December 9, 1993 or in WO 94/26764 to Imbach et al.

The term "pharmaceutically acceptable salts" refers to  
5 physiologically and pharmaceutically acceptable salts of the compounds of the invention: i.e., salts that retain the desired biological activity of the parent compound and do not impart undesired toxicological effects thereto.

Pharmaceutically acceptable base addition salts are  
10 formed with metals or amines, such as alkali and alkaline earth metals or organic amines. Examples of metals used as cations are sodium, potassium, magnesium, calcium, and the like. Examples of suitable amines are  
15 N,N'-dibenzylethylenediamine, chlorprocaine, choline, diethanolamine, dicyclohexylamine, ethylenediamine, N-methylglucamine, and procaine (see, for example, Berge et al., "Pharmaceutical Salts," *J. of Pharma Sci.*, **1977**, 66, 1-19). The base addition salts of said acidic compounds are prepared by contacting the free acid form with a sufficient  
20 amount of the desired base to produce the salt in the conventional manner. The free acid form may be regenerated by contacting the salt form with an acid and isolating the free acid in the conventional manner. The free acid forms differ from their respective salt forms somewhat in certain  
25 physical properties such as solubility in polar solvents, but otherwise the salts are equivalent to their respective free acid for purposes of the present invention. As used herein, a "pharmaceutical addition salt" includes a pharmaceutically acceptable salt of an acid form of one of the components of  
30 the compositions of the invention. These include organic or inorganic acid salts of the amines. Preferred acid salts are the hydrochlorides, acetates, salicylates, nitrates and phosphates. Other suitable pharmaceutically acceptable salts are well known to those skilled in the art and include basic  
35 salts of a variety of inorganic and organic acids, such as,

for example, with inorganic acids, such as for example hydrochloric acid, hydrobromic acid, sulfuric acid or phosphoric acid; with organic carboxylic, sulfonic, sulfo or phospho acids or N-substituted sulfamic acids, for example  
5 acetic acid, propionic acid, glycolic acid, succinic acid, maleic acid, hydroxymaleic acid, methylemaleic acid, fumaric acid, malic acid, tartaric acid, lactic acid, oxalic acid, gluconic acid, glucaric acid, glucuronic acid, citric acid, benzoic acid, cinnamic acid, mandelic acid, salicylic acid,  
10 4-aminosalicylic acid, 2-phenoxybenzoic acid, 2-acetoxybenzoic acid, embonic acid, nicotinic acid or isonicotinic acid; and with amino acids, such as the 20 alpha-amino acids involved in the synthesis of proteins in nature, for example glutamic acid or aspartic acid, and also with phenylacetic acid,  
15 methanesulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, ethane-1,2-disulfonic acid, benzenesulfonic acid, 4-methylbenzenesulfoc acid, naphthalene-2-sulfonic acid, naphthalene-1,5-disulfonic acid, 2- or 3-phosphoglycerate, glucose-6-phosphate,  
20 N-cyclohexylsulfamic acid (with the formation of cyclamates), or with other acid organic compounds, such as ascorbic acid. Pharmaceutically acceptable salts of compounds may also be prepared with a pharmaceutically acceptable cation. Suitable pharmaceutically acceptable cations are well known to those  
25 skilled in the art and include alkaline, alkaline earth, ammonium and quaternary ammonium cations. Carbonates or hydrogen carbonates are also possible.

For oligonucleotides, preferred examples of pharmaceutically acceptable salts include but are not limited  
30 to (a) salts formed with cations such as sodium, potassium, ammonium, magnesium, calcium, polyamines such as spermine and spermidine, etc.; (b) acid addition salts formed with inorganic acids, for example hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid and the  
35 like; (c) salts formed with organic acids such as, for

example, acetic acid, oxalic acid, tartaric acid, succinic acid, maleic acid, fumaric acid, gluconic acid, citric acid, malic acid, ascorbic acid, benzoic acid, tannic acid, palmitic acid, alginic acid, polyglutamic acid, naphthalenesulfonic acid, methanesulfonic acid, p-toluenesulfonic acid, naphthalenedisulfonic acid, polygalacturonic acid, and the like; and (d) salts formed from elemental anions such as chlorine, bromine, and iodine.

The antisense compounds of the present invention can be utilized for diagnostics, therapeutics, prophylaxis and as research reagents and kits. For therapeutics, an animal, preferably a human, suspected of having a disease or disorder which can be treated by modulating the expression of Survivin is treated by administering antisense compounds in accordance with this invention. The compounds of the invention can be utilized in pharmaceutical compositions by adding an effective amount of an antisense compound to a suitable pharmaceutically acceptable diluent or carrier. Use of the antisense compounds and methods of the invention may also be useful prophylactically, e.g., to prevent or delay infection, inflammation or tumor formation, for example.

The antisense compounds of the invention are useful for research and diagnostics, because these compounds hybridize to nucleic acids encoding Survivin, enabling sandwich and other assays to easily be constructed to exploit this fact.

Hybridization of the antisense oligonucleotides of the invention with a nucleic acid encoding Survivin can be detected by means known in the art. Such means may include conjugation of an enzyme to the oligonucleotide, radiolabelling of the oligonucleotide or any other suitable detection means. Kits using such detection means for detecting the level of Survivin in a sample may also be prepared.

The present invention also includes pharmaceutical compositions and formulations which include the antisense

compounds of the invention. The pharmaceutical compositions of the present invention may be administered in a number of ways depending upon whether local or systemic treatment is desired and upon the area to be treated. Administration may  
5 be topical (including ophthalmic and to mucous membranes including vaginal and rectal delivery), pulmonary, e.g., by inhalation or insufflation of powders or aerosols, including by nebulizer; intratracheal, intranasal, epidermal, intradermal and transdermal, oral or parenteral. Parenteral  
10 administration includes intravenous, intraarterial, subcutaneous, intraperitoneal or intramuscular injection, drip or infusion; or intracranial, e.g., intrathecal or intraventricular, administration. Oligonucleotides with at least one 2'-O-methoxyethyl modification are believed to be  
15 particularly useful for oral administration.

Pharmaceutical compositions and formulations for topical administration may include transdermal patches, ointments, lotions, creams, gels, drops, suppositories, sprays, liquids and powders. Conventional pharmaceutical carriers, aqueous,  
20 powder or oily bases, thickeners and the like may be necessary or desirable. Coated condoms, gloves and the like may also be useful.

Compositions and formulations for oral administration include powders or granules, suspensions or solutions in water  
25 or non-aqueous media, capsules, sachets or tablets. Thickeners, flavoring agents, diluents, emulsifiers, dispersing aids or binders may be desirable.

Compositions and formulations for parenteral, intrathecal or intraventricular administration may include  
30 sterile aqueous solutions which may also contain buffers, diluents and other suitable additives such as, but not limited to, penetration enhancers, carrier compounds and other pharmaceutically acceptable carriers or excipients.

Pharmaceutical compositions and/or formulations  
35 comprising the oligonucleotides of the present invention may



also include penetration enhancers in order to enhance the alimentary delivery of the oligonucleotides. Penetration enhancers may be classified as belonging to one of five broad categories, i.e., fatty acids, bile salts, chelating agents, 5 surfactants and non-surfactants (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, 8, 91-192; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7:1, 1-33). One or more penetration enhancers from one or more of these broad categories may be included.

10 Various fatty acids and their derivatives which act as penetration enhancers include, for example, oleic acid, lauric acid, capric acid, myristic acid, palmitic acid, stearic acid, linoleic acid, linolenic acid, dicaprate, tricaprate, recinleate, monoolein (a.k.a. 1-monooleoyl-rac-glycerol), 15 dilaurin, caprylic acid, arichidonic acid, glyceryl 1-monocaprate, 1-dodecylazacycloheptan-2-one, acylcarnitines, acylcholines, mono- and di-glycerides and physiologically acceptable salts thereof (i.e., oleate, laurate, caprate, myristate, palmitate, stearate, linoleate, etc.) (Lee et al., 20 *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, 8:2, 91-192; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7:1, 1-33; El-Hariri et al., *J. Pharm. Pharmacol.*, 1992, 44, 651-654). Examples of some presently preferred fatty acids are sodium caprate and sodium laurate, 25 used singly or in combination at concentrations of 0.5 to 5%.

The physiological roles of bile include the facilitation of dispersion and absorption of lipids and fat-soluble vitamins (Brunton, Chapter 38 In: *Goodman & Gilman's The Pharmacological Basis of Therapeutics*, 9th Ed., Hardman et 30 al., eds., McGraw-Hill, New York, NY, 1996, pages 934-935). Various natural bile salts, and their synthetic derivatives, act as penetration enhancers. Thus, the term "bile salt" includes any of the naturally occurring components of bile as well as any of their synthetic derivatives. Examples of

presently preferred bile salts are chenodeoxycholic acid (CDCA) and/or ursodeoxycholic acid (UDCA), generally used at concentrations of 0.5 to 2%.

Complex formulations comprising one or more penetration enhancers may be used. For example, bile salts may be used in combination with fatty acids to make complex formulations. Preferred combinations include CDCA combined with sodium caprate or sodium laurate (generally 0.5 to 5%).

Chelating agents include, but are not limited to, disodium ethylenediaminetetraacetate (EDTA), citric acid, salicylates (e.g., sodium salicylate, 5-methoxysalicylate and homovanilate), N-acyl derivatives of collagen, laureth-9 and N-amino acyl derivatives of beta-diketones (enamines) (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, 8:2, 92-192; Muranishi, *Critical Reviews in Therapeutic Drug Carrier Systems*, 1990, 7:1, 1-33; Buur et al., *J. Control Rel.*, 1990, 14, 43-51). Chelating agents have the added advantage of also serving as DNase inhibitors.

Surfactants include, for example, sodium lauryl sulfate, polyoxyethylene-9-lauryl ether and polyoxyethylene-20-cetyl ether (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, 8:2, 92-191); and perfluorochemical emulsions, such as FC-43 (Takahashi et al., *J. Pharm. Pharmacol.*, 1988, 40, 252-257).

Non-surfactants include, for example, unsaturated cyclic ureas, 1-alkyl- and 1-alkenylazacyclo-alkanone derivatives (Lee et al., *Critical Reviews in Therapeutic Drug Carrier Systems*, 1991, 8:2, 92-191); and non-steroidal anti-inflammatory agents such as diclofenac sodium, indomethacin and phenylbutazone (Yamashita et al., *J. Pharm. Pharmacol.*, 1987, 39, 621-626).

As used herein, "carrier compound" refers to a nucleic acid, or analog thereof, which is inert (i.e., does not possess biological activity per se) but is recognized as a

nucleic acid by *in vivo* processes that reduce the bioavailability of a nucleic acid having biological activity by, for example, degrading the biologically active nucleic acid or promoting its removal from circulation. The  
5 coadministration of a nucleic acid and a carrier compound, typically with an excess of the latter substance, can result in a substantial reduction of the amount of nucleic acid recovered in the liver, kidney or other extracirculatory reservoirs, presumably due to competition between the carrier  
10 compound and the nucleic acid for a common receptor. For example, the recovery of a partially phosphorothioated oligonucleotide in hepatic tissue is reduced when it is coadministered with polyinosinic acid, dextran sulfate, polycytidic acid or 4-acetamido-4'-isothiocyano-stilbene-  
15 2,2'-disulfonic acid (Miyao et al., *Antisense Res. Dev.*, 1995, 5, 115-121; Takakura et al., *Antisense & Nucl. Acid Drug Dev.*, 1996, 6, 177-183).

In contrast to a carrier compound, a "pharmaceutically acceptable carrier" (excipient) is a pharmaceutically  
20 acceptable solvent, suspending agent or any other pharmacologically inert vehicle for delivering one or more nucleic acids to an animal. The pharmaceutically acceptable carrier may be liquid or solid and is selected with the planned manner of administration in mind so as to provide for  
25 the desired bulk, consistency, etc., when combined with a nucleic acid and the other components of a given pharmaceutical composition. Typical pharmaceutically acceptable carriers include, but are not limited to, binding agents (e.g., pregelatinized maize starch, polyvinyl-  
30 pyrrolidone or hydroxypropyl methylcellulose, etc.); fillers (e.g., lactose and other sugars, microcrystalline cellulose, pectin, gelatin, calcium sulfate, ethyl cellulose, polyacrylates or calcium hydrogen phosphate, etc.); lubricants (e.g., magnesium stearate, talc, silica, colloidal silicon  
35 dioxide, stearic acid, metallic stearates, hydrogenated

vegetable oils, corn starch, polyethylene glycols, sodium benzoate, sodium acetate, etc.); disintegrates (e.g., starch, sodium starch glycolate, etc.); or wetting agents (e.g., sodium lauryl sulphate, etc.). Sustained release oral  
5 delivery systems and/or enteric coatings for orally administered dosage forms are described in U.S. Patents 4,704,295; 4,556,552; 4,309,406; and 4,309,404.

The compositions of the present invention may additionally contain other adjunct components conventionally  
10 found in pharmaceutical compositions, at their art-established usage levels. Thus, for example, the compositions may contain additional compatible pharmaceutically-active materials such as, e.g., antipruritics, astringents, local anesthetics or anti-inflammatory agents, or may contain additional materials  
15 useful in physically formulating various dosage forms of the composition of present invention, such as dyes, flavoring agents, preservatives, antioxidants, opacifiers, thickening agents and stabilizers. However, such materials, when added, should not unduly interfere with the biological activities of  
20 the components of the compositions of the invention.

Regardless of the method by which the antisense compounds of the invention are introduced into a patient, colloidal dispersion systems may be used as delivery vehicles to enhance the *in vivo* stability of the compounds and/or to  
25 target the compounds to a particular organ, tissue or cell type. Colloidal dispersion systems include, but are not limited to, macromolecule complexes, nanocapsules, microspheres, beads and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, liposomes and  
30 lipid:oligonucleotide complexes of uncharacterized structure. A preferred colloidal dispersion system is a plurality of liposomes. Liposomes are microscopic spheres having an aqueous core surrounded by one or more outer layer(s) made up of lipids arranged in a bilayer configuration (see, generally,  
35 Chonn et al., *Current Op. Biotech.*, 1995, 6, 698-708).

Certain embodiments of the invention provide for liposomes and other compositions containing (a) one or more antisense compounds and (b) one or more other chemotherapeutic agents which function by a non-antisense mechanism. Examples of such chemotherapeutic agents include but are not limited to daunorubicin, daunomycin, dactinomycin, doxorubicin, epirubicin, idarubicin, esorubicin, bleomycin, mafosfamide, ifosfamide, cytosine arabinoside, bis-chloroethylnitrosurea, busulfan, mitomycin C, actinomycin D, mithramycin, prednisone, hydroxyprogesterone, testosterone, tamoxifen, dacarbazine, procarbazine, hexamethylmelamine, pentamethylmelamine, mitoxantrone, amsacrine, chlorambucil, methylcyclohexylnitrosurea, nitrogen mustards, melphalan, cyclophosphamide, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-azacytidine, hydroxyurea, deoxycoformycin, 4-hydroxyperoxycyclophosphoramide, 5-fluorouracil (5-FU), 5-fluorodeoxyuridine (5-FUdR), methotrexate (MTX), colchicine, taxol, vincristine, vinblastine, etoposide (VP-16), trimetrexate, irinotecan, topotecan, gemcitabine, teniposide, cisplatin and diethylstilbestrol (DES). See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed. 1987, pp. 1206-1228, Berkow et al., eds., Rahway, N.J. When used with the compounds of the invention, such chemotherapeutic agents may be used individually (e.g., 5-FU and oligonucleotide), sequentially (e.g., 5-FU and oligonucleotide for a period of time followed by MTX and oligonucleotide), or in combination with one or more other such chemotherapeutic agents (e.g., 5-FU, MTX and oligonucleotide, or 5-FU, radiotherapy and oligonucleotide).

Anti-inflammatory drugs, including but not limited to nonsteroidal anti-inflammatory drugs and corticosteroids, and antiviral drugs, including but not limited to ribivirin, vidarabine, acyclovir and ganciclovir, may also be combined in compositions of the invention. See, generally, *The Merck Manual of Diagnosis and Therapy*, 15th Ed., Berkow et al.,

eds., 1987, Rahway, N.J., pages 2499-2506 and 46-49, respectively). Other non-antisense chemotherapeutic agents are also within the scope of this invention. Two or more combined compounds may be used together or sequentially.

5 In another related embodiment, compositions of the invention may contain one or more antisense compounds, particularly oligonucleotides, targeted to a first nucleic acid and one or more additional antisense compounds targeted to a second nucleic acid target. Examples of antisense  
10 oligonucleotides include, but are not limited to, those directed to the following targets as disclosed in the indicated U.S. Patents, or pending U.S. applications, which are commonly owned with the instant application and are hereby incorporated by reference, or the indicated published PCT  
15 applications: raf (WO 96/39415, WO 95/32987 and U.S. Patents 5,563,255 and 5,656,612), the p120 nucleolar antigen (WO 93/17125 and U.S. Patent 5,656,743), protein kinase C (WO 95/02069, WO 95/03833 and WO 93/19203), multidrug resistance-associated protein (WO 95/10938 and U.S. Patent 5,510,239),  
20 subunits of transcription factor AP-1 (pending application U.S. Serial No. 08/837,201, filed April 14, 1997), Jun kinases (pending application U.S. Serial No. 08/910,629, filed August 13, 1997), MDR-1 (multidrug resistance glycoprotein; pending application U.S. Serial No. 08/731,199, filed September 30,  
25 1997), HIV (U.S. Patents 5,166,195 and 5,591,600), herpesvirus (U.S. Patents 5,248,670 and 5,514,577), cytomegalovirus (U.S. Patents 5,442,049 and 5,591,720), papillomavirus (U.S. Patent 5,457,189), intercellular adhesion molecule-1 (ICAM-1) (U.S. Patent 5,514,788), 5-lipoxygenase (U.S. Patent 5,530,114) and  
30 influenza virus (U.S. Patent 5,580,767). Two or more combined compounds may be used together or sequentially.

The formulation of therapeutic compositions and their subsequent administration is believed to be within the skill of those in the art. Dosing is dependent on severity and  
35 responsiveness of the disease state to be treated, with the

course of treatment lasting from several days to several months, or until a cure is effected or a diminution of the disease state is achieved. Optimal dosing schedules can be calculated from measurements of drug accumulation in the body of the patient. Persons of ordinary skill can easily determine optimum dosages, dosing methodologies and repetition rates. Optimum dosages may vary depending on the relative potency of individual oligonucleotides, and can generally be estimated based on EC<sub>50</sub>s found to be effective in *in vitro* and *in vivo* animal models. In general, dosage is from 0.01  $\mu$ g to 100 g per kg of body weight, and may be given once or more daily, weekly, monthly or yearly, or even once every 2 to 20 years. Persons of ordinary skill in the art can easily estimate repetition rates for dosing based on measured residence times and concentrations of the drug in bodily fluids or tissues. Following successful treatment, it may be desirable to have the patient undergo maintenance therapy to prevent the recurrence of the disease state, wherein the oligonucleotide is administered in maintenance doses, ranging from 0.01  $\mu$ g to 100 g per kg of body weight, once or more daily, to once every 20 years.

While the present invention has been described with specificity in accordance with certain of its preferred embodiments, the following examples serve only to illustrate the invention and are not intended to limit the same.

## EXAMPLES

### Example 1

#### Nucleoside phosphoramidites for oligonucleotide synthesis deoxy and 2'-alkoxy amidites

2'-Deoxy and 2'-methoxy beta-cyanoethyldiisopropyl phosphoramidites were purchased from commercial sources (e.g. Chemgenes, Needham, MA or Glen Research, Inc. Sterling, VA).

Other 2'-O-alkoxy substituted nucleoside amidites are prepared as described in U.S. Patent 5,506,351, herein incorporated by reference. For oligonucleotides synthesized using 2'-alkoxy amidites, the standard cycle for unmodified oligonucleotides  
5 was utilized, except the wait step after pulse delivery of tetrazole and base was increased to 360 seconds.

Oligonucleotides containing 5-methyl-2'-deoxycytidine (5-Me-C) nucleotides were synthesized according to published methods [Sanghvi, et. al., *Nucleic Acids Research*, **1993**, *21*,  
10 3197-3203] using commercially available phosphoramidites (Glen Research, Sterling VA or ChemGenes, Needham, MA).

### 2'-Fluoro amidites

#### 2'-Fluorodeoxyadenosine amidites

2'-fluoro oligonucleotides were synthesized as described  
15 previously [Kawasaki, et. al., *J. Med. Chem.*, **1993**, *36*, 831-841] and U. S. Patent 5,670,633, herein incorporated by reference. Briefly, the protected nucleoside N6-benzoyl-2'-deoxy-2'-fluoroadenosine was synthesized utilizing commercially available 9-beta-D-arabinofuranosyladenine as  
20 starting material and by modifying literature procedures whereby the 2'-alpha-fluoro atom is introduced by a S<sub>N</sub>2-displacement of a 2'-beta-trityl group. Thus N6-benzoyl-9-beta-D-arabinofuranosyladenine was selectively protected in moderate yield as the 3',5'-ditetrahydropyranyl (THP)  
25 intermediate. Deprotection of the THP and N6-benzoyl groups was accomplished using standard methodologies and standard methods were used to obtain the 5'-dimethoxytrityl-(DMT) and 5'-DMT-3'-phosphoramidite intermediates.

#### 2'-Fluorodeoxyguanosine

30 The synthesis of 2'-deoxy-2'-fluoroguanosine was accomplished using tetraisopropylidisiloxanyl (TPDS) protected 9-beta-D-arabinofuranosylguanine as starting material, and



conversion to the intermediate diisobutyryl-arabinofuranosylguanosine. Deprotection of the TPDS group was followed by protection of the hydroxyl group with THP to give diisobutyryl di-THP protected arabinofuranosylguanine.

- 5 Selective O-deacylation and triflation was followed by treatment of the crude product with fluoride, then deprotection of the THP groups. Standard methodologies were used to obtain the 5'-DMT- and 5'-DMT-3'-phosphoramidites.

#### 2'-Fluorouridine

- 10 Synthesis of 2'-deoxy-2'-fluorouridine was accomplished by the modification of a literature procedure in which 2,2'-anhydro-1-beta-D-arabinofuranosyluracil was treated with 70% hydrogen fluoride-pyridine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-3'phosphoramidites.

- 15 **2'-Fluorodeoxycytidine**

2'-deoxy-2'-fluorocytidine was synthesized via amination of 2'-deoxy-2'-fluorouridine, followed by selective protection to give N4-benzoyl-2'-deoxy-2'-fluorocytidine. Standard procedures were used to obtain the 5'-DMT and 5'-DMT-  
20 3'phosphoramidites.

#### 2'-O-(2-Methoxyethyl) modified amidites

2'-O-Methoxyethyl-substituted nucleoside amidites are prepared as follows, or alternatively, as per the methods of Martin, P., *Helvetica Chimica Acta*, 1995, 78, 486-504.

25

#### 2,2'-Anhydro[1-(beta-D-arabinofuranosyl)-5-methyluridine]

- 5-Methyluridine (ribosylthymine, commercially available through Yamasa, Choshi, Japan) (72.0 g, 0.279 M), diphenyl-  
30 carbonate (90.0 g, 0.420 M) and sodium bicarbonate (2.0 g, 0.024 M) were added to DMF (300 mL). The mixture was heated

to reflux, with stirring, allowing the evolved carbon dioxide gas to be released in a controlled manner. After 1 hour, the slightly darkened solution was concentrated under reduced pressure. The resulting syrup was poured into diethylether 5 (2.5 L), with stirring. The product formed a gum. The ether was decanted and the residue was dissolved in a minimum amount of methanol (ca. 400 mL). The solution was poured into fresh ether (2.5 L) to yield a stiff gum. The ether was decanted and the gum was dried in a vacuum oven (60°C at 1 mm Hg for 24 10 h) to give a solid that was crushed to a light tan powder (57 g, 85% crude yield). The NMR spectrum was consistent with the structure, contaminated with phenol as its sodium salt (ca. 5%). The material was used as is for further reactions (or it can be purified further by column chromatography using a 15 gradient of methanol in ethyl acetate (10-25%) to give a white solid, mp 222-4°C).

#### 2'-O-Methoxyethyl-5-methyluridine

2,2'-Anhydro-5-methyluridine (195 g, 0.81 M), tris(2-methoxyethyl)borate (231 g, 0.98 M) and 2-methoxyethanol (1.2 20 L) were added to a 2 L stainless steel pressure vessel and placed in a pre-heated oil bath at 160°C. After heating for 48 hours at 155-160°C, the vessel was opened and the solution evaporated to dryness and triturated with MeOH (200 mL). The residue was suspended in hot acetone (1 L). The insoluble 25 salts were filtered, washed with acetone (150 mL) and the filtrate evaporated. The residue (280 g) was dissolved in CH<sub>3</sub>CN (600 mL) and evaporated. A silica gel column (3 kg) was packed in CH<sub>2</sub>Cl<sub>2</sub>/Acetone/MeOH (20:5:3) containing 0.5% Et<sub>3</sub>NH. The residue was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (250 mL) and adsorbed onto 30 silica (150 g) prior to loading onto the column. The product was eluted with the packing solvent to give 160 g (63%) of product. Additional material was obtained by reworking impure fractions.

**2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine**

2'-O-Methoxyethyl-5-methyluridine (160 g, 0.506 M) was co-evaporated with pyridine (250 mL) and the dried residue dissolved in pyridine (1.3 L). A first aliquot of 5 dimethoxytrityl chloride (94.3 g, 0.278 M) was added and the mixture stirred at room temperature for one hour. A second aliquot of dimethoxytrityl chloride (94.3 g, 0.278 M) was added and the reaction stirred for an additional one hour. Methanol (170 mL) was then added to stop the reaction. HPLC 10 showed the presence of approximately 70% product. The solvent was evaporated and triturated with CH<sub>3</sub>CN (200 mL). The residue was dissolved in CHCl<sub>3</sub> (1.5 L) and extracted with 2x500 mL of saturated NaHCO<sub>3</sub> and 2x500 mL of saturated NaCl. The organic phase was dried over Na<sub>2</sub>SO<sub>4</sub>, filtered and 15 evaporated. 275 g of residue was obtained. The residue was purified on a 3.5 kg silica gel column, packed and eluted with EtOAc/Hexane/Acetone (5:5:1) containing 0.5% Et<sub>3</sub>NH. The pure fractions were evaporated to give 164 g of product. Approximately 20 g additional was obtained from the impure 20 fractions to give a total yield of 183 g (57%).

**3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine**

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (106 g, 0.167 M), DMF/pyridine (750 mL of a 3:1 mixture 25 prepared from 562 mL of DMF and 188 mL of pyridine) and acetic anhydride (24.38 mL, 0.258 M) were combined and stirred at room temperature for 24 hours. The reaction was monitored by tlc by first quenching the tlc sample with the addition of MeOH. Upon completion of the reaction, as judged by tlc, MeOH 30 (50 mL) was added and the mixture evaporated at 35°C. The residue was dissolved in CHCl<sub>3</sub> (800 mL) and extracted with 2x200 mL of saturated sodium bicarbonate and 2x200 mL of saturated NaCl. The water layers were back extracted with 200 mL of CHCl<sub>3</sub>. The combined organics were dried with sodium

sulfate and evaporated to give 122 g of residue (approx. 90% product). The residue was purified on a 3.5 kg silica gel column and eluted using EtOAc/Hexane(4:1). Pure product fractions were evaporated to yield 96 g (84%). An additional 5 1.5 g was recovered from later fractions.

**3'-O-Acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyl-4-triazoleuridine**

A first solution was prepared by dissolving 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyluridine (96 g, 10 0.144 M) in CH<sub>3</sub>CN (700 mL) and set aside.

Triethylamine (189 mL, 1.44 M) was added to a solution of triazole (90 g, 1.3 M) in CH<sub>3</sub>CN (1 L), cooled to -5°C and stirred for 0.5 hours using an overhead stirrer. POCl<sub>3</sub> was added dropwise, over a 30 minute period, to the stirred 15 solution maintained at 0-10°C, and the resulting mixture stirred for an additional 2 hours. The first solution was added dropwise, over a 45 minute period, to the latter solution. The resulting reaction mixture was stored overnight in a cold room. Salts were filtered from the reaction mixture 20 and the solution was evaporated. The residue was dissolved in EtOAc (1 L) and the insoluble solids were removed by filtration. The filtrate was washed with 1x300 mL of NaHCO<sub>3</sub> and 2x300 mL of saturated NaCl, dried over sodium sulfate and evaporated. The residue was triturated with EtOAc to give the 25 title compound.

**2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine**

A solution of 3'-O-acetyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methyl-4-triazoleuridine (103 g, 0.141 M) in dioxane (500 mL) and NH<sub>4</sub>OH (30 mL) was stirred at room 30 temperature for 2 hours. The dioxane solution was evaporated and the residue azeotroped with MeOH (2x200 mL). The residue was dissolved in MeOH (300 mL) and transferred to a 2 liter stainless steel pressure vessel. MeOH (400 mL) saturated with

NH<sub>3</sub> gas was added and the vessel heated to 100EC for 2 hours (tlc showed complete conversion). The vessel contents were evaporated to dryness and the residue was dissolved in EtOAc (500 mL) and washed once with saturated NaCl (200 mL). The  
5 organics were dried over sodium sulfate and the solvent was evaporated to give 85 g (95%) of the title compound.

**N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine**

2'-O-Methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine  
10 (85 g, 0.134 M) was dissolved in DMF (800 mL) and benzoic anhydride (37.2 g, 0.165 M) was added with stirring. After stirring for 3 hours, tlc showed the reaction to be approximately 95% complete. The solvent was evaporated and the residue azeotroped with MeOH (200 mL). The residue was  
15 dissolved in CHCl<sub>3</sub> (700 mL) and extracted with saturated NaHCO<sub>3</sub> (2x300 mL) and saturated NaCl (2x300 mL), dried over MgSO<sub>4</sub> and evaporated to give a residue (96 g). The residue was chromatographed on a 1.5 kg silica column using EtOAc/Hexane (1:1) containing 0.5% Et<sub>3</sub>NH as the eluting solvent. The pure  
20 product fractions were evaporated to give 90 g (90%) of the title compound.

**N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-methylcytidine-3'-amidite**

N4-Benzoyl-2'-O-methoxyethyl-5'-O-dimethoxytrityl-5-  
25 methylcytidine (74 g, 0.10 M) was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1 L). Tetrazole diisopropylamine (7.1 g) and 2-cyanoethoxy-tetra-(isopropyl)phosphite (40.5 mL, 0.123 M) were added with stirring, under a nitrogen atmosphere. The resulting mixture was stirred for 20 hours at room temperature (tlc showed the  
30 reaction to be 95% complete). The reaction mixture was extracted with saturated NaHCO<sub>3</sub> (1x300 mL) and saturated NaCl (3x300 mL). The aqueous washes were back-extracted with CH<sub>2</sub>Cl<sub>2</sub>

(300 mL), and the extracts were combined, dried over  $\text{MgSO}_4$  and concentrated. The residue obtained was chromatographed on a 1.5 kg silica column using EtOAc/Hexane (3:1) as the eluting solvent. The pure fractions were combined to give 90.6 g  
5 (87%) of the title compound.

**2'-(Aminooxyethyl) nucleoside amidites and 2'-(dimethylaminooxyethyl) nucleoside amidites**

Aminooxyethyl and dimethylaminooxyethyl amidites are prepared as per the methods of United States patent  
10 applications serial number 10/037,143, filed February 14, 1998, and serial number 09/016,520, filed January 30, 1998, each of which is commonly owned with the instant application and is herein incorporated by reference.

**15 Example 2**

**Oligonucleotide synthesis**

Unsubstituted and substituted phosphodiester ( $\text{P}=\text{O}$ ) oligonucleotides are synthesized on an automated DNA synthesizer (Applied Biosystems model 380B) using standard  
20 phosphoramidite chemistry with oxidation by iodine.

Phosphorothioates ( $\text{P}=\text{S}$ ) are synthesized as for the phosphodiester oligonucleotides except the standard oxidation bottle was replaced by 0.2 M solution of 3H-1,2-benzodithiole-3-one 1,1-dioxide in acetonitrile for the stepwise thiation  
25 of the phosphite linkages. The thiation wait step was increased to 68 sec and was followed by the capping step. After cleavage from the CPG column and deblocking in concentrated ammonium hydroxide at  $55^\circ\text{C}$  (18 hours), the oligonucleotides were purified by precipitating twice with 2.5  
30 volumes of ethanol from a 0.5 M NaCl solution. Phosphinate oligonucleotides are prepared as described in U.S. Patent 5,508,270, herein incorporated by reference.

Alkyl phosphonate oligonucleotides are prepared as described in U.S. Patent 4,469,863, herein incorporated by reference.

3'-Deoxy-3'-methylene phosphonate oligonucleotides are prepared as described in U.S. Patents 5,610,289 or 5,625,050, herein incorporated by reference.

Phosphoramidite oligonucleotides are prepared as described in U.S. Patent, 5,256,775 or U.S. Patent 5,366,878, herein incorporated by reference.

Alkylphosphonothioate oligonucleotides are prepared as described in published PCT applications PCT/US94/00902 and PCT/US93/06976 (published as WO 94/17093 and WO 94/02499, respectively), herein incorporated by reference. 3'-Deoxy-3'-amino phosphoramidate oligonucleotides are prepared as described in U.S. Patent 5,476,925, herein incorporated by reference.

Phosphotriester oligonucleotides are prepared as described in U.S. Patent 5,023,243, herein incorporated by reference.

Borano phosphate oligonucleotides are prepared as described in U.S. Patents 5,130,302 and 5,177,198, both herein incorporated by reference.

### Example 3

#### Oligonucleoside synthesis

Methylenemethylimino linked oligonucleosides, also identified as MMI linked oligonucleosides, methylenedimethylhydrazo linked oligonucleosides, also identified as MDH linked oligonucleosides, and methylenecarbonylamino linked oligonucleosides, also identified as amide-3 linked oligonucleosides, and methyleneaminocarbonyl linked oligonucleosides, also identified as amide-4 linked oligonucleosides, as well as mixed backbone compounds having, for instance, alternating MMI and P=O or P=S linkages are prepared as described in U.S. Patents 5,378,825, 5,386,023, 5,489,677,

5,602,240 and 5,610,289, all of which are herein incorporated by reference.

Formacetal and thioformacetal linked oligonucleosides are prepared as described in U.S. Patents 5,264,562 and 5 5,264,564, herein incorporated by reference.

Ethylene oxide linked oligonucleosides are prepared as described in U.S. Patent 5,223,618, herein incorporated by reference.

#### **Example 4**

##### **10 PNA synthesis**

Peptide nucleic acids (PNAs) are prepared in accordance with any of the various procedures referred to in Peptide Nucleic Acids (PNA): Synthesis, Properties and Potential Applications, *Bioorganic & Medicinal Chemistry*, 1996, 4, 5-23. 15 They may also be prepared in accordance with U.S. Patents 5,539,082, 5,700,922, and 5,719,262, herein incorporated by reference.

#### **Example 5**

##### **Synthesis of chimeric oligonucleotides**

20 Chimeric oligonucleotides, oligonucleosides or mixed oligonucleotides/oligonucleosides of the invention can be of several different types. These include a first type wherein the "gap" segment of linked nucleosides is positioned between 5' and 3' "wing" segments of linked nucleosides and a second 25 "open end" type wherein the "gap" segment is located at either the 3' or the 5' terminus of the oligomeric compound. Oligonucleotides of the first type are also known in the art as "gapmers" or gapped oligonucleotides. Oligonucleotides of the second type are also known in the art as "hemimers" or 30 "wingmers".



**[2'-O-Me] - [2'-deoxy] - [2'-O-Me] chimeric phosphorothioate oligonucleotides**

Chimeric oligonucleotides having 2'-O-alkyl phosphorothioate and 2'-deoxy phosphorothioate oligonucleotide  
5 segments are synthesized using an Applied Biosystems automated DNA synthesizer Model 380B, as above. Oligonucleotides are synthesized using the automated synthesizer and 2'-deoxy-5'-dimethoxytrityl-3'-O-phosphoramidite for the DNA portion and 5'-dimethoxytrityl-2'-O-methyl-3'-O-phosphoramidite for 5' and  
10 3' wings. The standard synthesis cycle is modified by increasing the wait step after the delivery of tetrazole and base to 600 s repeated four times for RNA and twice for 2'-O-methyl. The fully protected oligonucleotide is cleaved from the support and the phosphate group is deprotected in 3:1  
15 Ammonia/Ethanol at room temperature overnight then lyophilized to dryness. Treatment in methanolic ammonia for 24 hours at room temperature is then done to deprotect all bases and sample was again lyophilized to dryness. The pellet is resuspended in 1M TBAF in THF for 24 hours at room temperature  
20 to deprotect the 2' positions. The reaction is then quenched with 1M TEAA and the sample is then reduced to 1/2 volume by rotovac before being desalted on a G25 size exclusion column. The oligo recovered is then analyzed spectrophotometrically for yield and for purity by capillary electrophoresis and by  
25 mass spectrometry.

**[2'-O-(2-Methoxyethyl)] - [2'-deoxy] - [2'-O-(Methoxyethyl)] chimeric phosphorothioate oligonucleotides**

[2'-O-(2-methoxyethyl)] - [2'-deoxy] - [-2'-O-(methoxyethyl)] chimeric phosphorothioate oligonucleotides were  
30 prepared as per the procedure above for the 2'-O-methyl chimeric oligonucleotide, with the substitution of 2'-O-(methoxyethyl) amidites for the 2'-O-methyl amidites.

**[2'-O-(2-Methoxyethyl)Phosphodiester] - [2'-deoxy  
Phosphorothioate] - [2'-O-(2-Methoxyethyl)  
Phosphodiester] chimeric oligonucleotides**

[2'-O-(2-methoxyethyl phosphodiester) - [2'-deoxy phos-  
5 phorothioate] - [2'-O-(methoxyethyl) phosphodiester] chimeric  
oligonucleotides are prepared as per the above procedure for  
the 2'-O-methyl chimeric oligonucleotide with the substitution  
of 2'-O-(methoxyethyl) amidites for the 2'-O-methyl amidites,  
oxidization with iodine to generate the phosphodiester  
10 internucleotide linkages within the wing portions of the  
chimeric structures and sulfurization utilizing 3,4-dihydro-2H-  
benzodithiole-3-one 1,1 dioxide (Beaucage Reagent) to generate  
the phosphorothioate internucleotide linkages for the center  
gap.

15 Other chimeric oligonucleotides, chimeric oligonucleo-  
sides and mixed chimeric oligonucleotides/oligonucleosides are  
synthesized according to U. S. Patent 5,623,065, herein  
incorporated by reference.

**20 Example 6**

**Oligonucleotide isolation**

After cleavage from the controlled pore glass column  
(Applied Biosystems) and deblocking in concentrated ammonium  
hydroxide at 55°C for 18 hours, the oligonucleotides or  
25 oligonucleosides are purified by precipitation twice out of  
0.5 M NaCl with 2.5 volumes ethanol. Synthesized  
oligonucleotides were analyzed by polyacrylamide gel  
electrophoresis on denaturing gels and judged to be at least  
85% full length material. The relative amounts of  
30 phosphorothioate and phosphodiester linkages obtained in  
synthesis were periodically checked by <sup>31</sup>P nuclear magnetic  
resonance spectroscopy, and for some studies oligonucleotides  
were purified by HPLC, as described by Chiang et al., *J. Biol.*  
*Chem.* **1991**, 266, 18162-18171. Results obtained with HPLC-

purified material were similar to those obtained with non-HPLC purified material.

#### Example 7

##### Oligonucleotide synthesis - 96 well plate format

5 Oligonucleotides were synthesized via solid phase P(III) phosphoramidite chemistry on an automated synthesizer capable of assembling 96 sequences simultaneously in a standard 96 well format. Phosphodiester internucleotide linkages were afforded by oxidation with aqueous iodine. Phosphorothioate  
10 internucleotide linkages were generated by sulfurization utilizing 3,4-dihydro-2H-benzothiole-3-one 1,1-dioxide (Beaucage Reagent) in anhydrous acetonitrile. Standard base-protected beta-cyanoethyl-diisopropyl phosphoramidites were purchased from commercial vendors (e.g. PE-Applied Biosystems, Foster  
15 City, CA, or Pharmacia, Piscataway, NJ). Non-standard nucleosides are synthesized as per known literature or patented methods. They are utilized as base protected beta-cyanoethyl-diisopropyl phosphoramidites.

Oligonucleotides were cleaved from support and  
20 deprotected with concentrated  $\text{NH}_4\text{OH}$  at elevated temperature (55-60°C) for 12-16 hours and the released product then dried in vacuo. The dried product was then re-suspended in sterile water to afford a master plate from which all analytical and test plate samples are then diluted utilizing robotic  
25 pipettors.

#### Example 8

##### Oligonucleotide analysis - 96 well plate format

The concentration of oligonucleotide in each well was assessed by dilution of samples and UV absorption  
30 spectroscopy. The full-length integrity of the individual products was evaluated by capillary electrophoresis (CE) in either the 96 well format (Beckman P/ACEJ MDQ) or, for

individually prepared samples, on a commercial CE apparatus (e.g., Beckman P/ACEJ 5000, ABI 270). Base and backbone composition was confirmed by mass analysis of the compounds utilizing electrospray-mass spectroscopy. All assay test  
5 plates were diluted from the master plate using single and multi-channel robotic pipettors. Plates were judged to be acceptable if at least 85% of the compounds on the plate were at least 85% full length.

#### Example 9

##### 10 Cell culture and oligonucleotide treatment

The effect of antisense compounds on target nucleic acid expression can be tested in any of a variety of cell types provided that the target nucleic acid is present at measurable levels. This can be routinely determined using, for example,  
15 PCR or Northern blot analysis. The following four cell types are provided for illustrative purposes, but other cell types can be routinely used.

##### T-24 cells:

The transitional cell bladder carcinoma cell line T-24  
20 was obtained from the American Type Culture Collection (ATCC) (Manassas, VA). T-24 cells were routinely cultured in complete McCoy's 5A basal media (Gibco/Life Technologies, Gaithersburg, MD) supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD), penicillin 100  
25 units per mL, and streptomycin 100 micrograms per mL (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 90% confluence. Cells were seeded into 96-well plates (Falcon-Primaria #3872) at a density of 7000 cells/well for  
30 use in RT-PCR analysis.

For Northern blotting or other analysis, cells may be seeded onto 100 mm or other standard tissue culture plates and

treated similarly, using appropriate volumes of medium and oligonucleotide.

A549 cells:

The human lung carcinoma cell line A549 was obtained  
5 from the American Type Culture Collection (ATCC) (Manassas,  
VA). A549 cells were routinely cultured in DMEM basal media  
(Gibco/Life Technologies, Gaithersburg, MD) supplemented with  
10% fetal calf serum (Gibco/Life Technologies, Gaithersburg,  
MD), penicillin 100 units per mL, and streptomycin 100  
10 micrograms per mL (Gibco/Life Technologies, Gaithersburg, MD).  
Cells were routinely passaged by trypsinization and dilution  
when they reached 90% confluence.

NHDF cells:

Human neonatal dermal fibroblast (NHDF) were obtained  
15 from the Clonetics Corporation (Walkersville MD). NHDFs were  
routinely maintained in Fibroblast Growth Medium (Clonetics  
Corporation, Walkersville MD) supplemented as recommended by  
the supplier. Cells were maintained for up to 10 passages as  
recommended by the supplier.

20 HEK cells:

Human embryonic keratinocytes (HEK) were obtained from  
the Clonetics Corporation (Walkersville MD). HEKs were  
routinely maintained in Keratinocyte Growth Medium (Clonetics  
Corporation, Walkersville MD) formulated as recommended by the  
25 supplier. Cells were routinely maintained for up to 10  
passages as recommended by the supplier.

3T3-L1 cells:

The mouse embryonic adipocyte-like cell line 3T3-L1 was  
obtained from the American Type Culure Collection (Manassas,  
30 VA). 3T3-L1 cells were routinely cultured in DMEM, high  
glucose (Gibco/Life Technologies, Gaithersburg, MD)

supplemented with 10% fetal calf serum (Gibco/Life Technologies, Gaithersburg, MD). Cells were routinely passaged by trypsinization and dilution when they reached 80% confluence. Cells were seeded into 96-well plates (Falcon-  
5 Primaria #3872) at a density of 4000 cells/well for use in RT-PCR analysis.

For Northern blotting or other analyses, cells may be seeded onto 100 mm or other standard tissue culture plates and treated similarly, using appropriate volumes of medium and  
10 oligonucleotide.

Treatment with antisense compounds:

When cells reached 80% confluency, they were treated with oligonucleotide. For cells grown in 96-well plates, wells were washed once with 200  $\mu$ L OPTI-MEMJ-1 reduced-serum  
15 medium (Gibco BRL) and then treated with 130  $\mu$ L of OPTI-MEMJ-1 containing 3.75  $\mu$ g/mL LIPOFECTINJ (Gibco BRL) and the desired oligonucleotide at a final concentration of 150 nM. After 4 hours of treatment, the medium was replaced with fresh medium. Cells were harvested 16 hours after oligonucleotide treatment.

20 The concentration of oligonucleotide used varies from cell line to cell line. To determine the optimal oligonucleotide concentration for a particular cell line, the cells are treated with a positive control oligonucleotide at a range of concentrations. For human cells the positive  
25 control oligonucleotide is ISIS 13920, **TCCGTCATCGCTCCTCAGGG**, SEQ ID NO: 1, a 2'-O-methoxyethyl gapmer (2'-O-methoxyethyls shown in bold) with a phosphorothioate backbone which is targeted to human H-ras. For mouse or rat cells the positive  
30 control oligonucleotide is ISIS 15770, **ATGCATTCTGCCCCCAAGGA**, SEQ ID NO: 2, a 2'-O-methoxyethyl gapmer (2'-O-methoxyethyls shown in bold) with a phosphorothioate backbone which is targeted to both mouse and rat c-raf. The concentration of positive control oligonucleotide that results in 80%

inhibition of H-ras (for ISIS 13920) or c-raf (for ISIS 15770) mRNA is then utilized as the screening concentration for new oligonucleotides in subsequent experiments for that cell line. If 80% inhibition is not achieved, the lowest concentration of positive control oligonucleotide that results in 60% inhibition of H-ras or c-raf mRNA is then utilized as the oligonucleotide screening concentration in subsequent experiments for that cell line. If 60% inhibition is not achieved, that particular cell line is deemed as unsuitable for oligonucleotide transfection experiments.

#### Example 10

##### Analysis of oligonucleotide inhibition of Survivin expression

Antisense modulation of Survivin expression can be assayed in a variety of ways known in the art. For example, Survivin mRNA levels can be quantitated by, e.g., Northern blot analysis, competitive polymerase chain reaction (PCR), or real-time PCR (RT-PCR). Real-time quantitative PCR is presently preferred. RNA analysis can be performed on total cellular RNA or poly(A)+ mRNA. Methods of RNA isolation are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.1.1-4.2.9 and 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Northern blot analysis is routine in the art and is taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.2.1-4.2.9, John Wiley & Sons, Inc., 1996. Real-time quantitative (PCR) can be conveniently accomplished using the commercially available ABI PRISMJ 7700 Sequence Detection System, available from PE-Applied Biosystems, Foster City, CA and used according to manufacturer's instructions. Other methods of PCR are also known in the art.

Survivin protein levels can be quantitated in a variety of ways well known in the art, such as immunoprecipitation, Western blot analysis (immunoblotting), ELISA or fluorescence-

activated cell sorting (FACS). Antibodies directed to Survivin can be identified and obtained from a variety of sources, such as the MSRS catalog of antibodies (Aerie Corporation, Birmingham, MI), or can be prepared via  
5 conventional antibody generation methods. Methods for preparation of polyclonal antisera are taught in, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.12.1-11.12.9, John Wiley & Sons, Inc., 1997. Preparation of monoclonal antibodies is taught in, for  
10 example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.4.1-11.11.5, John Wiley & Sons, Inc., 1997.

Immunoprecipitation methods are standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current*  
15 *Protocols in Molecular Biology*, Volume 2, pp. 10.16.1-10.16.11, John Wiley & Sons, Inc., 1998. Western blot (immunoblot) analysis is standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 10.8.1-10.8.21, John Wiley  
20 & Sons, Inc., 1997. Enzyme-linked immunosorbent assays (ELISA) are standard in the art and can be found at, for example, Ausubel, F.M. et al., *Current Protocols in Molecular Biology*, Volume 2, pp. 11.2.1-11.2.22, John Wiley & Sons, Inc., 1991.

## 25 **Example 11**

### **Poly(A)+ mRNA isolation**

Poly(A)+ mRNA was isolated according to Miura et al., *Clin. Chem.*, 1996, 42, 1758-1764. Other methods for poly(A)+ mRNA isolation are taught in, for example, Ausubel, F.M. et  
30 al., *Current Protocols in Molecular Biology*, Volume 1, pp. 4.5.1-4.5.3, John Wiley & Sons, Inc., 1993. Briefly, for cells grown on 96-well plates, growth medium was removed from the cells and each well was washed with 200  $\mu$ L cold PBS. 60



5  $\mu$ L lysis buffer (10 mM Tris-HCl, pH 7.6, 1 mM EDTA, 0.5 M NaCl, 0.5% NP-40, 20 mM vanadyl-ribonucleoside complex) was added to each well, the plate was gently agitated and then incubated at room temperature for five minutes. 55  $\mu$ L of lysate was transferred to Oligo d(T) coated 96-well plates (AGCT Inc., Irvine CA). Plates were incubated for 60 minutes at room temperature, washed 3 times with 200  $\mu$ L of wash buffer (10 mM Tris-HCl pH 7.6, 1 mM EDTA, 0.3 M NaCl). After the final wash, the plate was blotted on paper towels to remove excess wash buffer and then air-dried for 5 minutes. 60  $\mu$ L of elution buffer (5 mM Tris-HCl pH 7.6), preheated to 70°C was added to each well, the plate was incubated on a 90°C hot plate for 5 minutes, and the eluate was then transferred to a fresh 96-well plate.

15 Cells grown on 100 mm or other standard plates may be treated similarly, using appropriate volumes of all solutions.

#### Example 12

##### Total RNA isolation

20 Total mRNA was isolated using an RNEASY 96J kit and buffers purchased from Qiagen Inc. (Valencia CA) following the manufacturer's recommended procedures. Briefly, for cells grown on 96-well plates, growth medium was removed from the cells and each well was washed with 200  $\mu$ L cold PBS. 100  $\mu$ L Buffer RLT was added to each well and the plate vigorously agitated for 20 seconds. 100  $\mu$ L of 70% ethanol was then added to each well and the contents mixed by pipetting three times up and down. The samples were then transferred to the RNEASY 96J well plate attached to a QIAVACJ manifold fitted with a waste collection tray and attached to a vacuum source. Vacuum was applied for 15 seconds. 1 mL of Buffer RW1 was added to each well of the RNEASY 96J plate and the vacuum again applied for 15 seconds. 1 mL of Buffer RPE was then added to each well of the RNEASY 96J plate and the vacuum applied for a

period of 15 seconds. The Buffer RPE wash was then repeated and the vacuum was applied for an additional 10 minutes. The plate was then removed from the QIAVACJ manifold and blotted dry on paper towels. The plate was then re-attached to the  
5 QIAVACJ manifold fitted with a collection tube rack containing 1.2 mL collection tubes. RNA was then eluted by pipetting 60  $\mu$ L water into each well, incubating 1 minute, and then applying the vacuum for 30 seconds. The elution step was repeated with an additional 60  $\mu$ L water.

10 **Example 13**

**Real-time quantitative PCR analysis of Survivin mRNA levels**

Quantitation of Survivin mRNA levels was determined by real-time quantitative PCR using the ABI PRISMJ 7700 Sequence Detection System (PE-Applied Biosystems, Foster City, CA)  
15 according to manufacturer's instructions. This is a closed-tube, non-gel-based, fluorescence detection system which allows high-throughput quantitation of polymerase chain reaction (PCR) products in real-time. As opposed to standard PCR, in which amplification products are quantitated after the  
20 PCR is completed, products in real-time quantitative PCR are quantitated as they accumulate. This is accomplished by including in the PCR reaction an oligonucleotide probe that anneals specifically between the forward and reverse PCR primers, and contains two fluorescent dyes. A reporter dye  
25 (e.g., JOE or FAM, obtained from either Operon Technologies Inc., Alameda, CA or PE-Applied Biosystems, Foster City, CA) is attached to the 5' end of the probe and a quencher dye (e.g., TAMRA, obtained from either Operon Technologies Inc., Alameda, CA or PE-Applied Biosystems, Foster City, CA) is  
30 attached to the 3' end of the probe. When the probe and dyes are intact, reporter dye emission is quenched by the proximity of the 3' quencher dye. During amplification, annealing of the probe to the target sequence creates a substrate that can

be cleaved by the 5'-exonuclease activity of Taq polymerase. During the extension phase of the PCR amplification cycle, cleavage of the probe by Taq polymerase releases the reporter dye from the remainder of the probe (and hence from the quencher moiety) and a sequence-specific fluorescent signal is generated. With each cycle, additional reporter dye molecules are cleaved from their respective probes, and the fluorescence intensity is monitored at regular (six-second) intervals by laser optics built into the ABI PRISMJ 7700 Sequence Detection System. In each assay, a series of parallel reactions containing serial dilutions of mRNA from untreated control samples generates a standard curve that is used to quantitate the percent inhibition after antisense oligonucleotide treatment of test samples.

PCR reagents were obtained from PE-Applied Biosystems, Foster City, CA. RT-PCR reactions were carried out by adding 25  $\mu$ L PCR cocktail (1x TAQMANJ buffer A, 5.5 mM  $MgCl_2$ , 300  $\mu$ M each of dATP, dCTP and dGTP, 600  $\mu$ M of dUTP, 100 nM each of forward primer, reverse primer, and probe, 20 Units RNase inhibitor, 1.25 Units AMPLITAQ GOLDJ, and 12.5 Units MuLV reverse transcriptase) to 96 well plates containing 25  $\mu$ L poly(A) mRNA solution. The RT reaction was carried out by incubation for 30 minutes at 48°C. Following a 10 minute incubation at 95EC to activate the AMPLITAQ GOLDJ, 40 cycles of a two-step PCR protocol were carried out: 95°C for 15 seconds (denaturation) followed by 60EC for 1.5 minutes (annealing/extension). Probes and primers to human Survivin were designed to hybridize to a human Survivin sequence, using published sequence information (GenBank accession number U75285, incorporated herein as SEQ ID NO:3). For human Survivin the PCR primers were:

forward primer: AAGGACCACCGCATCTCTACA (SEQ ID NO: 4)

reverse primer: CCAAGTCTGGCTCGTTCTCAGT (SEQ ID NO: 5) and the

PCR probe was: FAM-CGAGGCTGGCTTCATCCACTGCC-TAMRA (SEQ ID NO:

6) where FAM (PE-Applied Biosystems, Foster City, CA) is the fluorescent reporter dye) and TAMRA (PE-Applied Biosystems, Foster City, CA) is the quencher dye. For human GAPDH the PCR primers were:

- 5 forward primer: GAAGGTGAAGGTCGGAGTC (SEQ ID NO: 7)  
reverse primer: GAAGATGGTGATGGGATTTTC (SEQ ID NO: 8) and the  
PCR probe was: 5' JOE-CAAGCTTCCCGTTCTCAGCC-TAMRA 3' (SEQ ID  
NO: 9) where JOE (PE-Applied Biosystems, Foster City, CA) is  
the fluorescent reporter dye) and TAMRA (PE-Applied  
10 Biosystems, Foster City, CA) is the quencher dye.

- Probes and primers to mouse Survivin were designed to  
hybridize to a mouse Survivin sequence, using published  
sequence information (GenBank accession number AB013819,  
incorporated herein as SEQ ID NO: 10). For mouse Survivin the  
15 PCR primers were:

- forward primer: CCGAGAACGAGCCTGATTTG (SEQ ID NO: 11)  
reverse primer: GGGAGTGCTTTCTATGCTCCTCTA (SEQ ID NO: 12) and  
the PCR probe was: FAM-TAAGGAATTGGAAGGCTGGGAACCCG-TAMRA  
(SEQ ID NO: 13) where FAM (PE-Applied Biosystems, Foster City,  
20 CA) is the fluorescent reporter dye) and TAMRA (PE-Applied  
Biosystems, Foster City, CA) is the quencher dye. For mouse  
GAPDH the PCR primers were:  
forward primer: GGCAAATTCAACGGCACAGT (SEQ ID NO: 14)  
reverse primer: GGGTCTCGCTCCTGGAAGCT (SEQ ID NO: 15) and the  
25 PCR probe was: 5' JOE-AAGGCCGAGAATGGGAAGCTTGTCATC-TAMRA 3'  
(SEQ ID NO: 16) where JOE (PE-Applied Biosystems, Foster City,  
CA) is the fluorescent reporter dye) and TAMRA (PE-Applied  
Biosystems, Foster City, CA) is the quencher dye.

#### Example 14

#### 30 Northern blot analysis of Survivin mRNA levels

Eighteen hours after antisense treatment, cell  
monolayers were washed twice with cold PBS and lysed in 1 mL  
RNAzolJ (TEL-TEST "B" Inc., Friendswood, TX). Total RNA was  
prepared following manufacturer's recommended protocols.

Twenty micrograms of total RNA was fractionated by electrophoresis through 1.2% agarose gels containing 1.1% formaldehyde using a MOPS buffer system (AMRESCO, Inc. Solon, OH). RNA was transferred from the gel to HYBONDJ-N+ nylon 5 membranes (Amersham Pharmacia Biotech, Piscataway, NJ) by overnight capillary transfer using a Northern/Southern Transfer buffer system (TEL-TEST "B" Inc., Friendswood, TX). RNA transfer was confirmed by UV visualization. Membranes were fixed by UV cross-linking using a STRATALINKERJ UV 10 Crosslinker 2400 (Stratagene, Inc, La Jolla, CA) and then probed using QUICKHYBJ hybridization solution (Stratagene, La Jolla, CA) using manufacturer's recommendations for stringent conditions.

To detect human Survivin, a human Survivin specific 15 probe was prepared by PCR using the forward primer AAGGACCACCGCATCTCTACA (SEQ ID NO: 4) and the reverse primer CCAAGTCTGGCTCGTTCTCAGT (SEQ ID NO: 5). To normalize for variations in loading and transfer efficiency membranes were stripped and probed for human glyceraldehyde-3-phosphate 20 dehydrogenase (GAPDH) RNA (Clontech, Palo Alto, CA).

To detect mouse Survivin, a mouse Survivin specific probe was prepared by PCR using the forward primer CCGAGAACGAGCCTGATTTG (SEQ ID NO: 11) and the reverse primer GGGAGTGCTTTCTATGCTCCTCTA (SEQ ID NO: 12). To normalize for 25 variations in loading and transfer efficiency membranes were stripped and probed for mouse glyceraldehyde-3-phosphate dehydrogenase (GAPDH) RNA (Clontech, Palo Alto, CA).

#### **Example 15**

#### **Antisense inhibition of Survivin expression- phosphorothioate 30 oligodeoxynucleotides**

In accordance with the present invention, a series of oligonucleotides were designed to target different regions of the human Survivin RNA, using published sequences (GenBank accession number U75285, incorporated herein as SEQ ID NO: 3).

The oligonucleotides are shown in Table 1. Target sites are indicated by nucleotide numbers, as given in the sequence source reference (GenBank accession no. U75285), to which the oligonucleotide binds. All compounds in Table 1 are  
 5 oligodeoxynucleotides with phosphorothioate backbones (internucleoside linkages) throughout. All cytodines are 5-methylcytidines. The compounds were analyzed for effect on Survivin mRNA levels by quantitative real-time PCR as described in other examples herein. Data are averages from  
 10 three experiments. If present, "N.D." indicates "no data".

TABLE 1

Inhibition of human Survivin mRNA levels by  
 phosphorothioate oligodeoxynucleotides

	ISIS#	REGION	TARGET	SEQUENCE	% Inhibition	SEQ ID NO
			SITE			
15	23625	5'UTR	1	gcgattcaaactctggcgg	0	17
	23653	5' UTR	19	cctctgccaacgggtccc	4	18
	23654	5' UTR	75	tgagaaagggctgccagg	46	19
	23655	5' UTR	103	ttcttgaatgtagagatg	0	20
	23656	5' UTR	128	ggcgcagccctccaagaa	38	21
20	23657	Coding	194	caagtctggctcgttctc	0	22
	23658	Coding	226	tccagctccttgaagcag	32	23
	23659	Coding	249	ggctcgtcatctggctccc	36	24
	23660	Coding	306	gcttcttgacagaaagga	35	25
	23661	Coding	323	ggttaattcttcaaactg	0	26
25	23662	Coding	363	tcttggctctttctctgt	34	27
	23663	Coding	393	tcttattgttggtttcct	0	28
	23664	Coding	417	tcgcagtttcctcaaatt	37	29
	23665	Coding	438	cgatggcacggcgcaactt	72	30
	23666	Coding	511	cctggaagtggcgcagcc	16	31
30	23667	Coding	542	acaggaaggctggtggca	70	32
	23668	Coding	587	tttgaatgttgatctc	8	33
	23669	Coding	604	acagttgaaacatctaata	0	34
	23670	Coding	625	ctttcaagacaaaacagg	0	35
	23671	Coding	650	acaggcagaagcacctct	0	36
35	23672	Coding	682	aagcagccactgttacca	64	37
	23673	Coding	700	aaagagagagagagagag	18	38
	23674	Coding	758	tccctcacttctcacctg	29	39
	23675	3' UTR	777	agggacactgccttcttc	43	40

	ISIS#	REGION	TARGET	SEQUENCE	% Inhibition	SEQ ID NO
			SITE			
	23676	3' UTR	808	ccacgcgaacaaagctgt	62	41
	23677	3' UTR	825	actgtggaaggctctgcc	0	42
	23678	3' UTR	867	aggactgtgacagcctca	62	43
	23679	3' UTR	901	tcagattcaacaggcacc	0	44
5	23680	3' UTR	1016	attctctcatcacacaca	26	45
	23681	3' UTR	1054	tgttggttaaacagtagag	0	46
	23682	3' UTR	1099	tgtgctattctgtgaatt	20	47
	23683	3' UTR	1137	gacttagaatggctttgt	37	48
	23684	3' UTR	1178	ctgtctcctcatccacct	41	49
10	23685	3' UTR	1216	aaaaggagtatctgccag	39	50
	23686	3' UTR	1276	gaggagcggccagcatgt	47	51
	23687	3' UTR	1373	ggctgacagacacacggc	41	52
	23688	3' UTR	1405	ccgtgtggagaacgtgac	22	53
	23689	3' UTR	1479	tacgccagacttcagccc	1	54
15	23690	3' UTR	1514	atgacagggaggagggcg	0	55
	23691	3' UTR	1571	gccgagatgacctccaga	66	56

As shown in Table 1, SEQ ID NOs: 19, 21, 23, 24, 25, 27, 29, 30, 32, 37, 40, 41, 43, 48, 49, 50, 51, 52 and 56 demonstrated at least 30% inhibition of Survivin expression in this assay and are therefore preferred.

#### Example 16

#### Antisense inhibition of Survivin expression- phosphorothioate 2'-MOE gapmer oligonucleotides

In accordance with the present invention, a second series of oligonucleotides targeted to human Survivin were synthesized. The oligonucleotide sequences are shown in Table 2. Target sites are indicated by nucleotide numbers, as given in the sequence source reference (GenBank accession no. U75285), to which the oligonucleotide binds.

All compounds in Table 2 are chimeric oligonucleotides ("gapmers") 18 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by four-nucleotide "wings". The wings are composed of 2'-methoxyethyl (2'-MOE)nucleotides. The internucleoside (backbone) linkages

are phosphorothioate (P=S) throughout the oligonucleotide. All cytidine residues are 5-methylcytidines.

Data were obtained by real-time quantitative PCR as described in other examples herein and are averaged from three experiments. If present, "N.D." indicates "no data".

TABLE 2

Inhibition of human Survivin mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

ISIS#	REGION	TARGET	SEQUENCE	%	SEQ ID
23692	5' UTR	1	gcgattcaaactctggcgg	22	57
23693	5' UTR	19	cctctgccaacgggtccc	15	58
23694	5' UTR	75	tgagaaagggtctgccagg	11	59
23695	5' UTR	103	ttcttgaatgtagagatg	37	60
23696	5' UTR	128	ggcgcagccctccaagaa	16	61
23697	Coding	194	caagtctggctcgttctc	17	62
23698	Coding	226	tccagctccttgaagcag	0	63
23699	Coding	249	ggtcgtcatctggctccc	19	64
23700	Coding	306	gcttcttgacagaaagga	35	65
23701	Coding	323	ggttaattcttcaaactg	15	66
23702	Coding	363	tcttggtctctttctctgt	8	67
23703	Coding	393	tcttattgttggtttcct	41	68
23704	Coding	417	tcgcagtttctcctcaaatt	24	69
23705	Coding	438	cgatggcacggcgcaactt	72	70
23706	Coding	511	cctggaagtgggtgcagcc	4	71
23707	Coding	542	acaggaaggctggtggca	48	72
23708	Coding	587	tttgaaaatggtgatctc	2	73
23709	Coding	604	acagttgaaacatctaatt	28	74
23710	Coding	625	ctttcaagacaaaacagg	0	75
23711	Coding	650	acaggcagaagcacctct	38	76
23712	Coding	682	aagcagccactgttacca	27	77
23713	Coding	700	aaagagagagagagagag	0	78
23714	Coding	758	tccctcacttctcacctg	0	79
23715	3' UTR	777	agggacactgccttcttc	44	80
23716	3' UTR	808	ccacgcgaacaaagctgt	25	81
23717	3' UTR	825	actgtggaaggctctgcc	8	82
23718	3' UTR	867	aggactgtgacagcctca	49	83
23719	3' UTR	901	tcagattcaacaggcacc	0	84
23720	3' UTR	1016	attctctcatcacacaca	0	85



10	ISIS#	REGION	TARGET	SEQUENCE	%	SEQ ID
	23721	3' UTR	1054	tgttgttaaacagtagag	0	86
	23722	3' UTR	1099	tgtgctattctgtgaatt	80	87
	23723	3' UTR	1137	gacttagaatggctttgt	44	88
	23724	3' UTR	1178	ctgtctcctcatccacct	27	89
5	23725	3' UTR	1216	aaaaggagtatctgccag	21	90
	23726	3' UTR	1276	gaggagcggccagcatgt	39	91
	23727	3' UTR	1373	ggctgacagacacacggc	45	92
	23728	3' UTR	1405	ccgtgtggagaacgtgac	24	93
	23729	3' UTR	1479	tacgccagacttcagccc	25	94
10	23730	3' UTR	1514	atgacagggaggaggcg	0	95
	23731	3' UTR	1571	gccgagatgacctccaga	19	96

As shown in Table 2, SEQ ID NOs: 60, 65, 68, 70, 72, 76, 80, 83, 87, 88, 91 and 92 demonstrated at least 30% inhibition of Survivin expression in this experiment and are preferred.

#### Example 17

##### Antisense inhibition of Survivin expression- phosphorothioate 2'-MOE gapmer oligonucleotides

In accordance with the present invention, a third series of oligonucleotides targeted to human Survivin mRNA were synthesized. The oligonucleotide sequences are shown in Table 3. Target sites are indicated by nucleotide numbers to which the oligonucleotide binds. The human Survivin mRNA was generated by splicing nucleotides 2811-2921, 3174-3283, 5158-5275 and 11955-12044 from GenBank accession no. U75285 creating the complete human mRNA sequence herein incorporated as SEQ ID NO: 97.

All compounds in Table 3 are chimeric oligonucleotides ("gapmers") 18 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by four-nucleotide "wings". The wings are composed of 2'-methoxyethyl (2'-MOE)nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide. All

cytidine residues are 5-methylcytidines.

Data were obtained by real-time quantitative PCR as described in other examples herein and are averaged from three experiments. If present, "N.D." indicates "no data".

5

TABLE 3

Inhibition of human Survivin mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

	ISIS #	REGION	TARGET SITE	SEQUENCE	% Inhibition	SEQ ID NO
10	107289	Coding	14	gccaacgggtcccgcgat	5	98
	107290	Coding	35	catgccgcccgcgccacc	4	99
	107291	Coding	90	agatgcggtggtccttga	94	100
	107292	Coding	110	gggccagtctcttgaatgt	14	101
	107293	Coding	166	tggatgaagccagcctcg	0	102
15	107294	Coding	212	gcagaagaaacactgggc	0	103
	107295	Coding	233	ccagccttccagctcctt	0	104
	107296	Coding	283	caaccggacgaatgcttt	0	105
	107297	Coding	299	gacagaaaggaaagcgca	83	106
	107298	Coding	313	tcaaactgcttcttgaca	73	107
20	107299	Coding	329	accaagggttaattcttc	0	108
	107300	Coding	359	ggctctttctctgtccag	7	109
	107301	Coding	370	atcttgcttcttgctctt	4	110
	107302	Coding	398	ttcttcttattgttggt	11	111
	107303	Coding	412	gtttcctcaaattctttc	0	112
25	107304	Coding	421	ttcttcgcagtttctca	49	113
	107305	Coding	432	cacggcgcaactttcttcg	22	114
	107306	Coding	445	agctgctcgatggcacgg	7	115
	107307	Coding	495	ccactctgggaccaggca	0	116
	107308	Coding	514	aaccctggaagtggtgca	0	117
30	107309	Coding	529	tggcaccaggaataaac	0	118
	107310	Coding	566	tcctaagacattgctaag	1	119
	107311	Coding	579	tgttgatctcctttccta	3	120
	107312	Coding	590	taatttgaaaatgttgat	15	121
	107313	Coding	599	tgaaacatctaatttgaa	0	122
35	107314	Coding	613	aacaggagcacagttgaa	27	123
	107315	Coding	619	agacaaaacaggagcaca	0	124
	107316	Coding	630	tgccactttcaagacaaa	24	125
	107317	Coding	635	tctggtgccactttcaag	0	126
	107318	Coding	653	Tgcacaggcagaagcacc	15	127

	ISIS #	REGION	TARGET SITE	SEQUENCE	% Inhibition	SEQ ID NO
	107319	Coding	676	ccactgttaccagcagca	4	128
	107320	Coding	701	aaaagagagagagagaga	0	129
	107321	Coding	766	cttcttcctccctcactt	7	130
	107322	Coding	789	agctctagcaaaaggac	0	131
5	107323	Coding	814	ctctgcccacgcgaacaa	13	132
	107324	Coding	836	cagacacattcactgtgg	0	133
	107325	Coding	852	tcaacaacatgaggtcca	0	134
	107326	Coding	882	gccaagtccacactcagg	0	135
	107327	Coding	1039	gaggagccagggactctg	16	136
10	107328	Coding	1067	aataagaaagccatgttg	0	137
	107329	Coding	1080	acaattcaaacaaaataa	30	138
	107330	Coding	1081	aacaattcaaacaaaata	0	139
	107331	Coding	1082	taacaattcaaacaaaat	3	140
	107332	Coding	1083	ttaacaattcaaacaaaa	31	141
15	107333	Coding	1084	attaacaattcaaacaaa	9	142
	107334	Coding	1085	aattaacaattcaaacaa	10	143
	107335	Coding	1092	ttctgtgaattaacaatt	16	144
	107336	Coding	1093	attctgtgaattaacaat	0	145
	107337	Coding	1094	tattctgtgaattaacaa	25	146
20	107338	Coding	1095	ctattctgtgaattaaca	12	147
	107339	Coding	1096	gctattctgtgaattaac	14	148
	107340	Coding	1097	tgctattctgtgaattaa	14	149
	107341	Coding	1098	gtgctattctgtgaatta	8	150
	107342	Coding	1100	ttgtgctattctgtgaat	18	151
25	107343	Coding	1101	tttgtgctattctgtgaa	33	152
	107344	Coding	1102	gtttgtgctattctgtga	11	153
	107345	Coding	1103	agtttgtgctattctgtg	21	154
	107346	Coding	1104	tagtttgtgctattctgt	17	155
	107347	Coding	1105	gtagtttgtgctattctg	57	156
30	107348	Coding	1106	tgtagtttgtgctattct	6	157
	107349	Coding	1107	ttgtagtttgtgctattc	13	158
	107350	Coding	1108	attgtagtttgtgctatt	15	159
	107351	Coding	1109	aattgtagtttgtgctat	0	160
	107352	Coding	1110	taattgtagtttgtgcta	25	161
35	107353	Coding	1120	tgcttagttttaattgta	0	162
	107354	Coding	1144	ccccaatgacttagaatg	7	163
	107355	Coding	1163	cctgaagttcaccccggt	19	164
	107356	Coding	1184	tctattctgtctcctcat	0	165
	107357	Coding	1199	gacgcttcctatcactct	18	166
40	107358	Coding	1222	agtggaagaggaggtatc	0	167
	107359	Coding	1239	ctgtctaatacacacagca	0	168
	107360	Coding	1281	tgaggaggagcgccag	0	169

0918186 07300  
 100220 9918186

ISIS #	REGION	TARGET SITE	SEQUENCE	% Inhibition	SEQ ID NO
107361	Coding	1350	gcagcccagccagtcccc	0	170
107362	Coding	1379	aggttgggctgacagaca	1	171
107363	Coding	1399	ggagaacgtgacagatgt	23	172
107364	Coding	1425	gggcggactgcgtctctc	0	173
5 107365	Coding	1470	cttcagccctgcgggagc	0	174
107366	Coding	1488	ccatcatcttacgccaga	0	175
107367	Coding	1509	agggaggagggcgaatca	0	176
107368	Coding	1585	atttctcaggaacagccg	7	177

As shown in Table 3, SEQ ID NOs: 101, 106, 107, 113, 138,  
 10 141, 152 and 156 demonstrated at least 30% inhibition of human  
 Survivin expression in this assay and are preferred.

#### Example 18

**Antisense inhibition of mouse Survivin expression by  
 chimeric phosphorothioate oligonucleotides having 2'-MOE  
 15 wings and a deoxy gap.**

In accordance with the present invention, a series of  
 oligonucleotides were designed to target different regions of  
 the mouse Survivin RNA, using published sequences (GenBank  
 accession number AB013819, incorporated herein as SEQ ID NO:  
 20 10). The oligonucleotides are shown in Table 4. "Target  
 site" indicates the first (5'-most) nucleotide number on the  
 particular target sequence to which the oligonucleotide binds.  
 All compounds in Table 4 are chimeric oligonucleotides  
 ("gapmers") 20 nucleotides in length, composed of a central  
 25 "gap" region consisting of ten 2'-deoxynucleotides, which is  
 flanked on both sides (5' and 3' directions) by five-  
 nucleotide "wings". The wings are composed of 2'-methoxyethyl  
 (2'-MOE) nucleotides. The internucleoside (backbone) linkages  
 are phosphorothioate (P=S) throughout the oligonucleotide. All  
 30 cytidine residues are 5-methylcytidines. The compounds were  
 analyzed for their effect on mouse Survivin mRNA levels by  
 quantitative real-time PCR as described in other examples

herein. Data are averages from two experiments. If present, "N.D." indicates "no data".

TABLE 4

5 Inhibition of mouse Survivin mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

	ISIS #	REGION	TARGET SITE	SEQUENCE	% INHIBITION	SEQ ID NO
	114968	5'UTR	3	agagccccggccccctcgtg	0	178
10	114967	5'UTR	4	gagagccccggccccctcgt	0	179
	114966	5'UTR	16	agagcatgccgggagagccc	0	108
	114965	5'UTR	25	gcgcgccgcagagcatgccg	0	181
	114964	5'UTR	55	aaacgcaggattcaaatcgc	0	182
	114963	5'UTR	66	caagacgactcaaacgcagg	0	183
15	114962	5'UTR	68	gccaagacgactcaaacgca	0	184
	114961	Start Codon	92	catgatggcgtcaccacaac	0	185
	114972	Start Codon	101	cggagctcccatgatggcgt	27	186
	114960	Start Codon	104	cgccggagctcccatgatgg	47	187
	114959	Coding	171	ggaagggccagttcttgaag	35	188
20	114958	Coding	184	gcgcagtcctccaggaagg	0	189
	114957	Coding	186	aggcgcagtcctccaggaag	10	190
	114957	Coding	186	aggcgcagtcctccaggaag	6	191
	114971	Coding	189	tgcaggcgcagtcctccagg	30	192
	114956	Coding	249	aatcaggctcgttctcggtta	46	193
25	114955	Coding	259	cactgggccaatcaggctc	14	194
	114954	Coding	289	cagccttccaattccttaaa	0	195
	114953	Coding	300	catcgggttcccagccttcc	67	196
	114952	Coding	303	tgtcatcgggttcccagcct	83	197
	114951	Coding	315	cctctatcgggttgtcatcg	40	198
30	114950	Coding	327	gctttctatgctcctctatc	39	199
	114949	Coding	358	ttgacagtgaggaaggcgca	0	200
	114948	Coding	374	ttcttccatctgcttcttga	0	201
	114947	Coding	387	cactgacgggttagttcttcc	39	202
	114946	Coding	389	ttcactgacgggttagttctt	12	203
35	114945	Coding	394	aagaattcactgacgggttag	26	204
	114944	Coding	396	tcaagaattcactgacgggtt	38	205
	114943	Coding	465	cttcaaactctttttgcttg	10	206
	114942	Coding	497	ctcaattgactgacgggttag	48	207
	114941	Coding	498	gctcaattgactgacgggtta	39	208
40	114940	Coding	499	tgctcaattgactgacgggt	23	219
	114939	Stop	521	ggctcagcattaggcagcca	18	210

ISIS #	REGION	TARGET SITE	SEQUENCE	% INHIBITION	SEQ ID NO
114938	Stop Codon	531	tctcagcaaaggctcagcat	42	211
114937	3'UTR	601	gctaggaggccctggctgga	52	212
114936	3'UTR	613	ctctaagatcctgctaggag	39	213
114935	3'UTR	627	accactgtctccttctctaa	35	214
114934	3'UTR	642	atccagttttcaaaataccac	0	215
114933	3'UTR	649	at ttgatatccagttttcaa	20	216
114932	3'UTR	666	aaagcaaaacaaaaaatatt	7	217
114931	3'UTR	683	agagaggtagccacttttaa	45	218
114930	3'UTR	688	accaaagagaggtagccact	44	219
114929	3'UTR	713	cgtcacaaatagagcaaagcc	14	220
114970	3'UTR	721	taagtccacgtcacaaataga	7	221
114928	3'UTR	741	ttcatcacttccttattgct	8	222
114927	3'UTR	756	agagaacactgtcccttcat	15	223
114969	3'UTR	786	acaggcaccgacccccac	4	224
114926	3'UTR	801	gaaccaagaccttgacacagg	59	225
114925	3'UTR	812	tatcacaaatcagaaccaaga	34	226
114924	3'UTR	834	cattagcagccctgtatgga	18	227
114923	3'UTR	856	aaccacacttaccatgggc	52	228
114922	3'UTR	903	gtggtaggaaaactcatcag	64	229
114921	3'UTR	934	actttttcaagtgattttat	13	230

As shown in Table 4, SEQ ID NOs: 187, 188, 192, 193, 196, 197, 198, 199, 202, 205, 207, 208, 211, 212, 213, 214, 218, 219, 225, 226, 228 and 229 demonstrated at least 30% inhibition of mouse Survivin expression in this experiment and 25 are therefore preferred.

In accordance with the present invention, a second series of oligonucleotides were designed to target different regions of the mouse Survivin RNA, using published sequences (GenBank accession number AA717921, incorporated herein as SEQ ID NO: 231). The oligonucleotides are shown in Table 5. "Target site" indicates the first (5'-most) nucleotide number on the particular target sequence to which the oligonucleotide binds. All compounds in Table 5 are chimeric oligonucleotides ("gapmers") 20 nucleotides in length, composed of a central "gap" region consisting of ten 2'-deoxynucleotides, which is flanked on both sides (5' and 3' directions) by five-nucleotide "wings". The wings are composed of 2'-methoxyethyl

(2'-MOE) nucleotides. The internucleoside (backbone) linkages are phosphorothioate (P=S) throughout the oligonucleotide. All cytidine residues are 5-methylcytidines. The compounds were analyzed for their effect on mouse Survivin mRNA levels by quantitative real-time PCR as described in other examples herein. Data are averages from two experiments. If present, "N.D." indicates "no data".

TABLE 5

Inhibition of mouse Survivin mRNA levels by chimeric phosphorothioate oligonucleotides having 2'-MOE wings and a deoxy gap

ISIS #	REGION	TARGET SITE	SEQUENCE	% INHIBITION	SEQ ID NO
114920	5'UTR	2	aatcccagccaaggatccga	0	232
114919	5'UTR	21	cgtggtggctcacaccttta	1	233
15 114918	5'UTR	33	tttcaagccgggcgtggtgg	11	234
114917	5'UTR	57	acatatatatataaacat	0	235
114916	5'UTR	87	aattttccttccttgatttt	5	236
114915	5'UTR	105	tactgagctacaaactggaa	41	237
114914	5'UTR	108	acttactgagctacaaactg	0	238
20 114913	5'UTR	168	aagttattatTTTTgtattg	0	239
114912	5'UTR	169	aaagttattatTTTTgtatt	7	240
114911	5'UTR	184	taaatacattaaaaggaaagt	0	241
114910	5'UTR	197	catcgtggcaagataaatca	0	242
114909	5'UTR	229	gcctgtccagggtgagatgc	0	243
25 114908	5'UTR	231	ttgcctgtccagggtgagat	0	244
114907	5'UTR	240	gggccaggcttgccctgtcca	13	245
114906	Start	293	ggtctcctttgcctggaatg	23	246
114905	Start Codon	296	gttggtctcctttgcctgga	59	247

As shown in Table 5, SEQ ID NOS: 237 and 247 demonstrated at least 30% inhibition of mouse Survivin expression in this experiment and are therefore preferred.

#### Example 19

##### Western blot analysis of Survivin protein levels

Western blot analysis (immunoblot analysis) is carried out using standard methods. Cells are harvested 16-20 hours

after oligonucleotide treatment, washed once with PBS, suspended in Laemmli buffer (100  $\mu$ l/well), boiled for 5 minutes and loaded on a 16% SDS-PAGE gel. Gels are run for 1.5 hours at 150 V, and transferred to membrane for western blotting. Appropriate primary antibody directed to Survivin is used, with a radiolabelled or fluorescently labeled secondary antibody directed against the primary antibody species. Bands are visualized using a PHOSPHORIMAGER™ (Molecular Dynamics, Sunnyvale, CA).

#### 10 Example 20

##### Effect of antisense inhibition of Survivin on apoptosis

ISIS 23722 and a mismatch control, ISIS 28598 (TAAGCTGTTCTATGTGTT; SEQ ID NO: 248) were assayed for their effect on apoptosis in HeLa cells. The caspase inhibitor z-VAD.fmk was purchased from Calbiochem (La Jolla, CA) and used according to manufacturer's recommendations. In HeLa cells without oligonucleotide, approximately 4% of cells are hypodiploid (indicating DNA fragmentation, a measure of apoptosis). With the addition of ISIS 23722, approximately 22% of cells are hypodiploid, compared to approximately 11% with the mismatch oligonucleotide. In the presence of the caspase inhibitor z-VAD.fmk (42.8 mM), the percent of hypodiploid (apoptotic) cells drops to 3% without oligonucleotide, 6% with ISIS 23722 and 4% with the mismatch control. This demonstrates that antisense inhibition of Survivin increases apoptosis and that this effect is caspase-mediated.

#### Example 21

##### Effect of antisense inhibition of Survivin on cytokinesis

HeLa cells treated with an antisense oligonucleotide targeted to Survivin (ISIS 23722) can be observed to form large, multinucleated cells as a result of improper cell division. The mismatch control oligonucleotide did not have



this effect and cells appeared normal (comparable to untreated controls). This effect can be quantitated by flow cytometry.

Untreated cells or cells treated with the control oligonucleotide display two prominent peaks, representing populations of cells in the G1 phase and the G2/M phase of cell division, respectively. G1 cells have a single copy of their DNA (1x) and G2/M cells have two copies (2x). Over time from 24 hours to 72 hours, these 1x and 2x peaks remain virtually unchanged in cells treated with the control oligonucleotide or without oligonucleotide. However, in cells treated with the antisense oligonucleotide targeted to Survivin, the majority of cells have two copies of DNA by 24 hours after oligo treatment. This indicates that cell division is arrested. By 48 hours after treatment with this oligonucleotide, a 4x peak is approximately equal in size to the 1x and 2x peaks, indicating roughly equal numbers of cells with one, two and four copies of DNA. By 72 hours the largest peak is 16x, indicating that cells have 16 copies of their DNA and thus that division of the cytoplasm has not occurred for multiple generations. Thus inhibition of Survivin is shown to interfere with cytokinesis.

#### Example 22

##### Effect of antisense inhibition of Survivin on cell proliferation

Human HT1080 fibrosarcoma cells (American Type Culture Collection, CCL-121) were grown in minimal essential medium with 1% non-essential amino acids, 90% with 10% fetal bovine serum (Gibco BRL). Cells were electroporated (Electro Square Porator, Model T820, Biotechnologies and Experimental Research, BTX) with oligonucleotide at settings of 225 volts for 6 milliseconds with a single pulse and oligonucleotide concentrations of 1 to 30  $\mu$ M. ISIS 23722 (SEQ ID NO: 87) and the mismatch control ISIS 28598 (SEQ ID NO: 248) were used.

Cells were plated at 1500 cells/well immediately after electroporation and viable cells were measured by MTT assay at 24, 48, 72, 96 and 120 hours after electroporation. Growth rate (OD/hour) was plotted against oligonucleotide concentration. At an oligonucleotide concentration of 1  $\mu$ M, growth rates were virtually identical for ISIS 23722 and the control, ISIS 28598 (0.01726 and 0.01683, respectively. At 5  $\mu$ M oligonucleotide, the growth rate of the ISIS 23722-treated cells was 16.7% less than the control treated cells (0.01433 vs. 0.01728 OD/hour, respectively). At 10  $\mu$ M the growth rate of the ISIS 23722-treated cells was 45% less than the control treated cells (0.009677 vs. 0.01762 OD/hour, respectively). At 20  $\mu$ M the growth rate of the ISIS 23722-treated cells was 52% less than the control treated cells (0.007716 vs. 0.01620 OD/hour, respectively). At 30  $\mu$ M the growth rate of the ISIS 23722-treated cells was 54% less than the control treated cells (0.006562 vs. 0.01417 OD/hour, respectively). Thus treatment with antisense oligonucleotide targeted to Survivin was demonstrated to reduce the rate of tumor cell proliferation by over 50%.

In an similar experiment using a different control oligonucleotide, a 20mer random oligonucleotide (ISIS 29848, SEQ ID NO: 249; NNNNNNNNNNNNNNNNNNNNNN, wherein each N is a mixture of A, C, G and T) a similar result was obtained. Oligonucleotides were tested at concentrations of 0.5 to 20  $\mu$ M, and cell viability was again measured by MTT assay and growth rate (OD/hour) was calculated. At 0.5  $\mu$ M oligonucleotide concentrations, growth rates were similar for ISIS 23722 and control treated cells (0.01441 and 0.01342, respectively). At 10  $\mu$ M the growth rate of the ISIS 23722-treated cells was 57% less than the control treated cells (0.005568 vs. 0.01298 OD/hour, respectively). At 20  $\mu$ M the growth rate of the ISIS 23722-treated cells was 77% less than

the control treated cells (0.002433 vs. 0.01073 OD/hour, respectively). Thus treatment with antisense oligonucleotide targeted to Survivin was demonstrated to reduce the rate of tumor cell proliferation by over 75% compared to control.

5 A similar experiment was conducted in human MCF-7 breast carcinoma cells, testing ISIS 23722 and the random control ISIS 29848 at doses from 0.5 to 20  $\mu$ M. Cells were electroporated (Electro Square Porator, Model T820 manufactured by Biotechnologies and Experimental Research,  
10 BTX) at settings of 175 volts for 6 milliseconds with a single pulse with oligonucleotide and growth rates were calculated as described above. At 0.5  $\mu$ M oligonucleotide concentrations, growth rates were similar for ISIS 23722 and control treated cells (0.005959 and 0.005720, respectively). At 1  $\mu$ M  
15 oligonucleotide, growth rates were still relatively similar for ISIS 23722 and control treated cells (0.005938 and 0.005479, respectively). At 5  $\mu$ M oligonucleotide, growth rates were 0.002574 and 0.005676, respectively for ISIS 23722 and control treated cells. At 10  $\mu$ M the growth rate of the  
20 ISIS 23722-treated cells was 69% less than the control treated cells (0.001828 vs. 0.005901 OD/hour, respectively). At 20  $\mu$ M the growth rate of the ISIS 23722-treated cells was 64% less than the control treated cells (0.001523 vs. 0.004223 OD/hour, respectively). Thus treatment with antisense oligonucleotide  
25 targeted to Survivin was demonstrated to significantly reduce the rate of tumor cell proliferation in several tumor cell types.

### Example 23

#### Sensitization of cells to chemotherapeutic agent stimuli by

#### 30 ISIS 23722

ISIS 23722 (SEQ ID NO: 87) and a control oligonucleotide, ISIS 29848, a 20mer random oligonucleotide (ISIS 29848, SEQ ID NO: 249; NNNNNNNNNNNNNNNNNNNNNN, wherein each N is a mixture

of A, C, G and T) were assayed for their ability to sensitize cells to the effects of the chemotherapeutic agents, Taxol and Cisplatin.

Human HT1080 fibrosarcoma cells (American Type Culture  
5 Collection, CCL-121) were grown in minimal essential medium with 1% non-essential amino acids, 90% with 10% fetal bovine serum (Gibco BRL). Cells were treated with oligonucleotide at concentrations of 10 to 100 nM alone or in combination with Taxol (concentrations of 0.25 nM or 1 nM) or Cisplatin  
10 (concentrations of 5  $\mu$ M or 25  $\mu$ M). Treatment with Taxol or Cisplatin followed oligonucleotide treatment by 1-2 hr. Cells were plated at 1500 cells/well immediately after treatment and viable cells were measured by MTT assay at 12, 24, 36, 48, and 60 hours after treatment. Growth rate (OD/hour) is plotted  
15 against oligonucleotide and/or chemotherapeutic agent concentration.

A similar experiment was conducted in human MCF-7 breast carcinoma cells (American Type Culture Collection), testing ISIS 23722 and the random control ISIS 29848 at doses  
20 from 10 to 100 nM alone or in combination with Taxol (concentrations of 0.5 nM or 2nM) or Cisplatin (concentrations of 2.5  $\mu$ M or 15  $\mu$ M). Cells were grown in Dulbecco's Modified Eagles medium (low glucose), 90% with 10% fetal bovine serum (Gibco BRL). Treatment with Taxol or Cisplatin followed  
25 oligonucleotide treatment by 1-2 hr. Cells were plated at 2500 cells/well immediately after transfection and viable cells were measured by MTT assay at 12, 24, 36, 48, and 60 hours after treatment. Growth rate (OD/hour) is plotted against oligonucleotide and/or chemotherapeutic agent concentration.

### 30 Example 24

#### Mixed backbone version of active oligonucleotide ISIS 23722

An oligonucleotide having the same sequence as ISIS 23722 (SEQ ID NO:87) was synthesized, this time as a 2' MOE

gapmer with phosphodiester backbone linkages in the 2'MOE "wings" and phosphorothioate linkages in the 2'deoxy "gap". Both cytosines are 5-methylcytosines.

This compound is tested for its effects on cell proliferation, cytokinesis and sensitization to chemotherapeutic agents as described herein in previous examples.

#### Example 25

##### 10 Down-regulation of IL-11-induced survivin expression on human skin engrafted onto immunodeficient mice

The efficacy of anti-survivin antisense oligonucleotide cream to down-regulate IL-11 induced survivin expression in human skin grafts was examined in immunodeficient mice. SCID/beige mice were engrafted with human skin obtained from elective surgery and allowed to heal for 5 weeks. Four mice with 2 skin grafts each were used. The right graft of each animal received control (placebo) antisense oligonucleotide cream, while the left graft received the anti-survivin antisense oligonucleotide cream which comprised 5% of the 2'-MOE mixed backbone deoxyoligonucleotide ISIS 28599 (5'-TGTGCTATTCTGTGAATT-3', SEQ ID NO: 250) (nucleotides 1-4 and 15-18 are 2'-MOE; cytosines at positions 5 and 10 are 5-meC; nucleotides 1-3 and 16-18 are phosphodiester linkages; nucleotides 4-15 are phosphorothioate linkages. The dosing schedule consisted of regular dosing of 100  $\mu$ l/graft 3 times each day for 3 days. The morning of the 4<sup>th</sup> day, skin grafts were given their morning dose then 1 hour later injected intradermally with recombinant human IL-11 (500 ng) (Genetics Institute, Andover, MA). Antisense oligonucleotide cream was administered for 2 final doses. Animals were sacrificed on the morning of day 5. Grafts were harvested and formalin fixed for paraffin embedding.

Grafts from one animal were not identified in the blocks. The remaining three animals were evaluated by immunostaining for survivin and by routine hematoxylin and eosin histology. Immunostaining was performed on deparaffinized sections as  
5 previously described. Briefly, 5- $\mu$ m tissue sections were cut and slides were baked overnight in a 60°C oven. Sections were deparaffinized in xylene for 5 hours, washed twice in ethanol, and endogenous peroxidase activity was quenched with 1.5% hydrogen peroxide in methanol for 10 min. Slides were then  
10 placed in a 4-quart Wear-Ever pressure cooker (Mirro Co., Manitowoc, WI) containing 1.5 liters of 9 mM sodium citrate, pH 6.0 that had been brought to a boil. The lid was secured, and heating was continued (approx. 6 min) until the pressure valve released. Slides were gently cooled by filling the  
15 pressure cooker with tap water, and then washed 3 times with water and once with PBS, pH 7.0. Staining was performed using a primary rabbit polyclonal antibody against survivin at a concentration of 0.1  $\mu$ g/ml in PBS, pH 7.0, containing 0.5% bovine serum albumin (BSA) and 5% normal goat serum (Vector  
20 laboratories) and incubated overnight at 4°C using a Histostain-Plus kit (Zymed) with 3,3'-diaminobenzidine (DAB) as the chromogen.

The histology appeared normal and indistinguishable between the treated and control groups. Survivin expression  
25 showed a downregulation of expression in grafts treated with the survivin antisense oligonucleotide cream compared to controls. Both the dermal microvessels and the epidermal keratinocytes showed this downregulation when compared to control grafts.